DOCUMENT RESUME

ED 179 412 SE 029 435

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TITLE Huntington II Simulation Program - MALAR. Student Workbook, Teacher's Guide, and Resource Handbook.
INSTITUTION Digital Equipment Corp., Maynard, Mass.; State Univ. of New York, Stony Brook. Huntington Computer Project.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Mar 73
GRANT NSF-GW-5883
NOTE 95p.: For related documents, see SE 029 434-440 and ED 093 644-645: Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Biology: *Computer Assisted Instruction: Computer Programs: *Ecology: Environment: Game Theory: *Health Education: *Models: *Science Education: Secondary Education: *Simulation: Social Studies

ABSTRACT

Described is the computer model "MALAR" which deals with malaria and its eradication. A computer program allows the tenth- to twelfth-grade student to attempt to control a malaria epidemic. This simulation provides a context within which to study the biological, economic, social, political, and ecological aspects of a classic world health problem. (Author/RE)

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HUNTINGTON II Simulation Program—MALAR

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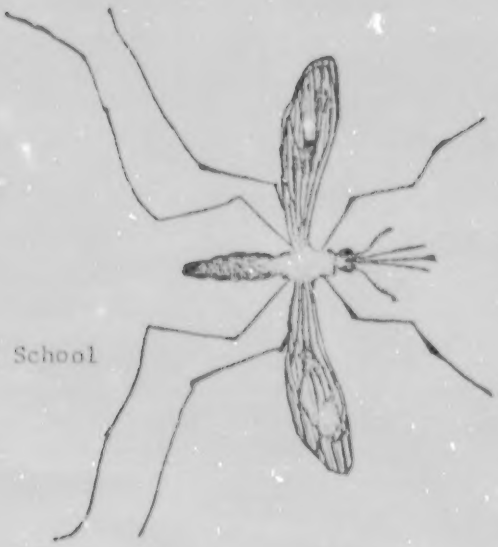
STUDENT MANUAL

MALARIA ERADICATION PROGRAM

MALAR



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HUNTINGTON TWO COMPUTER PROJECT

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1 March 1973

The work of the Huntington Two Computer Project is partially supported by the National Science Foundation, Grant GW-5883.

MALAR

I. INTRODUCTION TO THE UNIT

This unit focuses on malaria as a classic example of a world health problem. As you work with the materials in the unit and the computer program MALAR, you will learn about the medical and biological aspects of this health problem; but you will not stop there. You will begin to see that such a health problem involves many other kinds of concerns, and you will begin to look at it from points of view you may never have considered before. You will see how a health problem can also be a social, political, economic, and ecological problem, and you will begin to see just how complex is the business of achieving sound health for the world community.

Before you begin the exercises in the *STUDENT MANUAL*, your teacher may want you to spend some time reading or learning about the background materials presented in the *RESOURCE MANUAL* of the MALAR unit. These will give you a clearer understanding of the problem that will be presented to you in the computer program MALAR.

II. DESCRIPTION OF THE PROGRAM

MALAR simulates the *attack* phase of a malaria-eradication plan. It allows you to attempt to eradicate malaria from a given area within five years. You can try to do this with or without a budget limitation.

The conditions you have to work with appear in the "box" on the following page.

APPROX. POPULATION OF AREA: 100000

APPROX. NUMBER ILL WITH MALARIA: 25000

APPROX. NUMBER DEATHS/YEAR DUE TO MALARIA: 1000

GOAL: ERADICATE OR MINIMIZE THE MALARIA INCIDENCE IN THE AREA OVER A 5-YEAR PERIOD.

THE USER CAN MAKE USE OF A 4-TREATMENT METHOD, NAMELY:

1) To isolate in field hospitals those afflicted by malaria

2) To administer drugs to those who are ill

3) To use a pesticide to kill mosquitoes

4) To give preventive drugs to those still healthy

THESE ARE THE APPROXIMATE COSTS:

Field hospital of 20 beds: $2000 per year

Maximum malaria drug treatment: $2/year/person

Full anti-mosquito spray:

When using *DDT* - $ 75000 per year

When using *Malathion* - $231000 per year

When using *Propoxur* - $637500 per year

Preventive drug effective 1 year: 72c/person/year

(IF USING A BUDGET, YOU HAVE $500,000 TO WORK WITH.)

You are allowed to specify the extent to which you want to use each treatment method during each year of the five-year period. After you enter your decisions for a specific treatment method, the computer will print out the cost of that plan and the total amount of money you have used to that point. If the program is being used with a budget restriction, the computer will print out the balance remaining in the budget. After you have entered your decisions for all four types of treatment, the computer will tabulate the results of your five-year overall plan. It will specify for each year the number sick with malaria and the number of deaths caused by malaria. It will also print out the total amount spent over the five years, and if a budget restriction has been used, it will print the remaining balance. You may then: 1) get an evaluation of the effectiveness of each part of this plan, and 2) continue with the problem for another five years, or 3) start over, or 4) stop the program.

To be considered successful, you must have reduced the number of sick and the number of dead to a minimum.

NOTE: Keep in mind that the number of people who actually are sick in a given year is usually greater than the number given in the printout, since some have usually received treatment.

III. ASSUMPTIONS UNDER WHICH THE PROGRAM OPERATES

When the computer program MALAR was written, these major assumptions were made:

1) The area under treatment has been subject to malaria for a long time and thus a fraction of the population is assumed to have developed a slight resistance.

2) In any one year about 4% of those who are infected will die of complications due to malaria, if they are not treated with drugs.

3) The hospital confinement period for a malaria victim is about 1 year when there is no supply of drugs for treating the disease, and about 7 days when there is a sufficient supply.

4) Drug doses for the ill will be used first in the hospitals, if they exist. The surplus will be used on non-hospitalized victims.

5) Treatment is limited to this one area, and surrounding areas are not yet being treated.

6) The birthrate in the area is such that the deaths due to malaria do not significantly lower the population, and it remains at approximately 100,000 throughout the years.

7) The costs quoted in the program are based on data from the World Health Organization, and include administration and personnel costs.

8) The actual effectiveness of any treatment option cannot be 100%. This means, for example, that a 100% mosquito-eradication program will not wipe out 100% of the mosquitoes. This is so for a variety of reasons: some of them have a resistance to insecticides; human errors; and other factors. In a similar fashion the actual effectiveness is reduced in the other options.

9) If drugs are not used in the year ordered, there is a 25% loss (per year) due to pilferage, chemical breakdown, etc.

IV. NOTES ON RUNNING THE PROGRAM

You should not have any difficulty using the MALAR program. However, there are a few points that should be mentioned before you begin.

1) When you have finished putting in all your decisions, the computer will print out a table which will show the results of your five-year plan. The first line in the table is printed with a "0" in the column headed "year." This simply refers to the time before you began to implement your eradication plan. The other statistics in that line tell you the specific number of sick and dead at the time you came into the area to begin your eradication plan.

2) When the computer prints out the results of your five-year plan, the number of sick specified for any one year refers to the number of sick at the end of that year. The number of deaths printed refers to the actual number of deaths which occurred during that year.

V. COMPUTER LABORATORY MANUAL

A. Exploration Exercises: Effects of the Treatment Options

As you work with the MALAR program, it will be helpful for you to have some notion of what effects each treatment option has. Use the MALAR program without a budget restriction (Version 2) and try to determine what effect is had by each treatment option when it is used alone.

Run the program several times until you can answer the following questions:

1) Can the epidemic be eradicated successfully by using only one of the four options for all five years? If so, which one? If not, describe what happened when each option was used alone and try to explain the results.

2) Which of the four treatment possibilities was most effective when used alone in reducing both the number of sick and the number of dead? Which was least effective? Can you think of some reasons for these results?

Curative activities refer to those activities directed at the cure of malaria victims. *Preventive* activities are those which are intended to prevent those who are still healthy from getting malaria. Use the computer program without a financial limitation to help you answer the following questions.

3) Can the malaria epidemic be successfully eradicated by using only *curative* measures, that is, by just setting up hospitals and administering drugs to the ill? Describe the results of using such a plan, and try to explain your results.

4) Can the malaria epidemic be eradicated by using only *preventive* measures, that is, by just using mosquito control and immunization programs? Describe the results of using such a plan and try to explain your results.

5) Compare the results you got in 1) with those you got in 3) and 4). Was the combined use of hospital beds and drugs for the ill more effective than the use of hospital beds alone or drugs alone? Why or why not?

6) Once again comparing the results of 1) with those of 3) and 4), was the combined use of a mosquito-control plan and an immunization plan more effective than the use of either plan alone? Why or why not?

7) Using the information you got from the previous exercises, try to devise an eradication strategy. Do not use a budget restriction with MALAR (Version 2); simply try to wipe out the epidemic in five years. Spend as much money as you need. Record your strategy on a *PLAN OF ACTION* sheet, and describe the results obtained when you implemented it using MALAR. Below are the instructions for using the plan sheet on the next page.

DIRECTIONS FOR USING THE *PLAN OF ACTION* CHART

S-P-F-P-S

1. Check those treatments you wish to use in Column A.

   NOTE: Select only 1 type of pesticide (if you elect to control the mosquitoes).

2. Look at the figures in Column B. They indicate the cost of each treatment program.

3. For those programs checked in Column A, indicate the appropriate number of field hospitals, drugs for the sick, and preventive drugs which you want to use as well as the per cent of mosquitoes you wish to eliminate each year. Place your values in Column C.

4. In Column D, indicate the total number of years you wish to carry out each treatment program you selected in Column A.

5. Fill in the appropriate values in Column E. Each value is calculated by multiplying the appropriate values in column (B) X (C) X (D).

   EXAMPLE: If you select to use 1 hospital for 2 years, the value in Column E would be: 2000 X 1 X 2 = $4000.

6. Total up the values placed in Column E and put the answer in the blank at the bottom of the sheet.

7. Make sure that the grand total does not exceed the $500,000 limit. If it is greater than $500,000, you must alter your control program until it fits within the limits of the budget.

Use a different chart for each 5-year period.

You may attach the computer-printed results to the back of the *PLAN OF ACTION* chart.

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PLAN OF ACTION

A TREATMENT PROGRAM	B COST PER UNIT	C NUMBER UNITS or PERCENT EFFICIENCY	D TOTAL YEARS IN EFFECT	E TOTAL COST
FIELD HOSPITALS	2000	X____ hospitals/year	X____ years	= $____
DRUGS FOR SICK	2	X____ doses/year	X____ years	= $____
MOSQUITOES Pesticides (choose one): a) DDT b) Malathion c) Propoxur	 750 2310 6375	X____ % mosquitoes killed	X____ years	= $____
PREVENTIVE DRUGS	0.72	X____ doses/year	X____ years	= $____

(Amount allowed = $500,000 if following budget)

Grand Total = $____

RESULTS: _____

8) If your strategy did not work, try others until you find an effective one. Record it here and describe the results you obtained when you used it with MALAR.

PLAN OF ACTION

A TREATMENT PROGRAM	B COST PER UNIT	C NUMBER UNITS or PERCENT EFFICIENCY	D TOTAL YEARS IN EFFECT	E TOTAL COST
FIELD HOSPITALS	2000	X ___ hospitals/year	X ___ years	= $
DRUGS FOR SICK	2	X ___ doses/year	X ___ years	= $
MOSQUITOES Pesticides (choose one): a) DDT b) Malathion c) Propoxur	 750 2310 6375	 X ___ % mosquitoes killed	 X ___ years	 = $
PREVENTIVE DRUGS	0.72	X ___ doses/year	X ___ years	= $

(Amount allowed = $500,000 if following budget) Grand Total = $

RESULTS: _____

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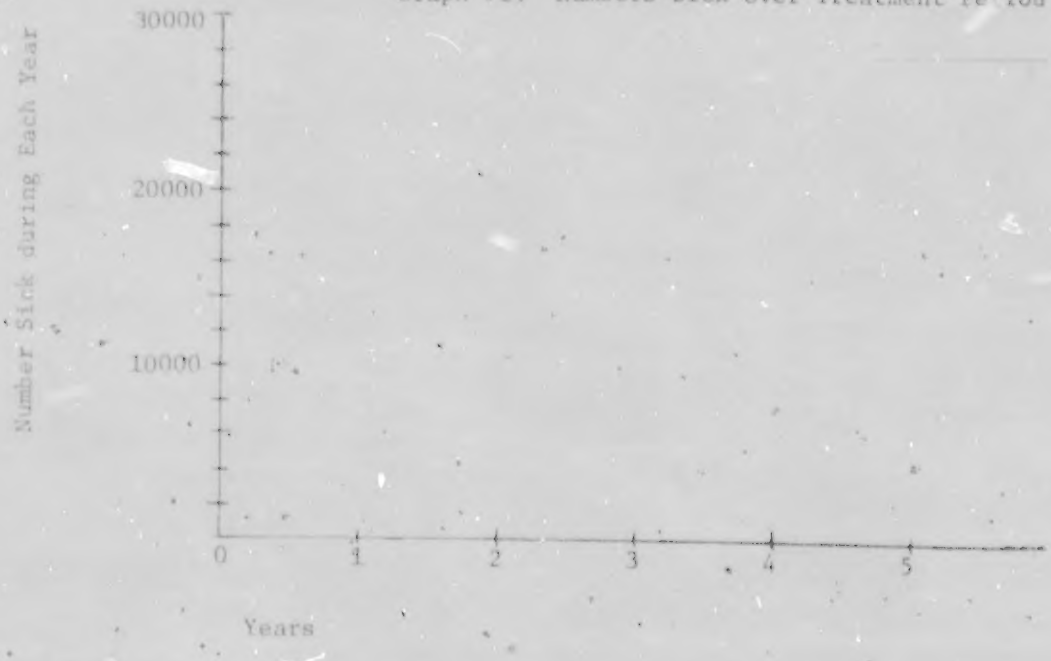
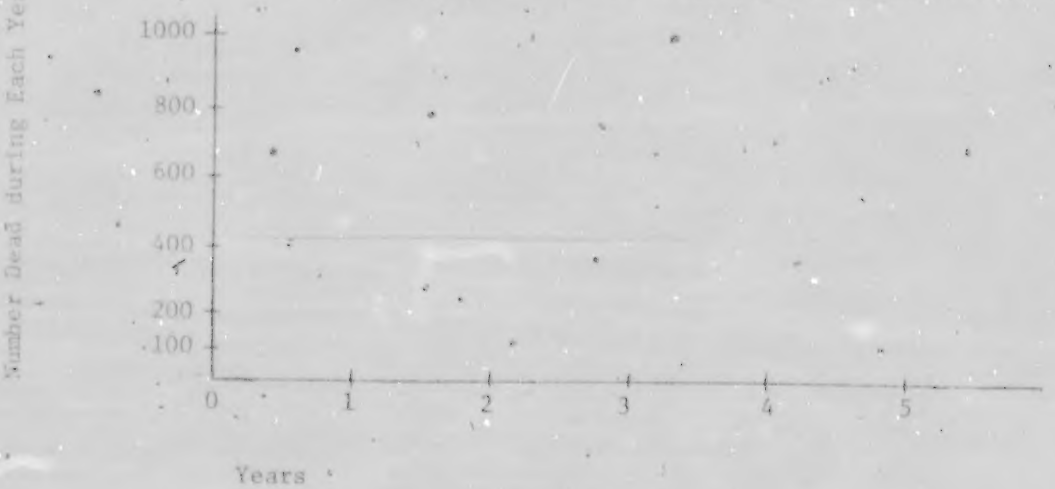
9) Using the axes below, make graphs which picture the results of your best five-year strategy. Use the data from your printouts.

Graph #1: Numbers Sick over Treatment Period



Graph #2: Numbers Dead over Treatment Period



Total Cost of Program: $_____

B. Exploration Exercises: Costs

In the previous exercises, you have not been concerned with costs. As you know, however, cost is a very real factor in any health maintenance effort. In the following exercises, you will be considering this financial dimension.

1) Use MALAR without a financial restriction to determine which of the four treatment options is cheapest when applied to the maximum degree you would (or can use) in the epidemic area described by the program. Which one is most expensive? (You can use your printouts from the previous exercise to answer this question.) Which of the options was most effective? Least effective? Is there any relationship between the cost and the effectiveness?

2) Keeping in mind the costs you found in the last question, devise a control strategy to use with a budget restriction of $500,000. Record your strategy here and describe the results obtained when you implemented it using MALAR. (See Instructions, p. 8 for help using the chart.)

PLAN OF ACTION

A TREATMENT PROGRAM	B COST PER UNIT	C NUMBER UNITS or PERCENT EFFICIENCY	D TOTAL YEARS IN EFFECT	E TOTAL COST
FIELD HOSPITALS	2000	X____hospitals/year	X____years	= $____
DRUGS FOR SICK	2	X____doses/year	X____years	= $____
MOSQUITOES Pesticides (choose one): a) DDT b) Malathion c) Dropwour	 750 2310 6375	X____% mosquitoes killed	X____years	= $____
PREVENTIVE DRUGS	0.72	X____doses/year	X____years	= $____
(Amount allowed = $500,000 if following budget)		Gr[illegible]		= $____

RESULTS: _____

3) If your plan in 2) did not work, try others until you find an effective one. Describe it here and the results obtained.

PLAN OF ACTION

A TREATMENT PROGRAM	B COST PER UNIT	C NUMBER UNITS or PERCENT EFFICIENCY	D TOTAL YEARS IN EFFECT	E TOTAL COST
FIELD HOSPITALS	2000	X____hospitals/year	X____years	= $_____
DRUGS FOR SICK	2	X____doses/year	X____years	= $_____
MOSQUITOES * Pesticides (choose one): a) DDT b) Malathion c) Propoxur	 750 2310 6375	X____% mosquitoes killed	X____years	= $_____
PREVENTIVE DRUGS	0.72	X____doses/year	X____years	= $_____

(Amount allowed = $500,000 if following budget) Grand Total = $_____

REMARKS: _____

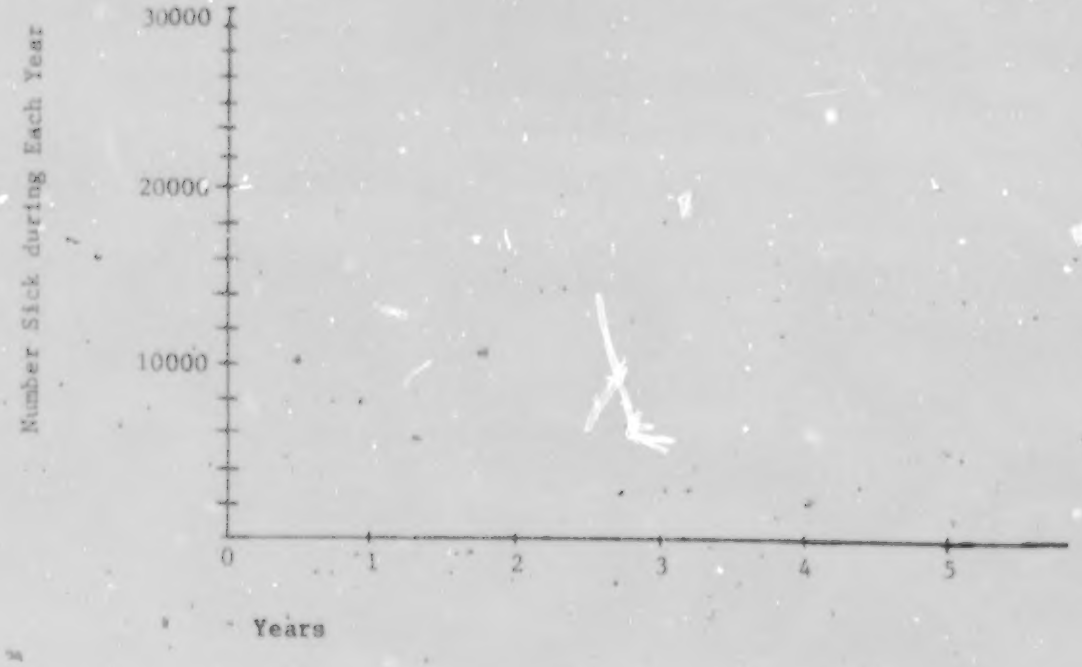
4) How did the best malaria eradication strategy you found for working with a budget differ from the best one you found for working without a budget?

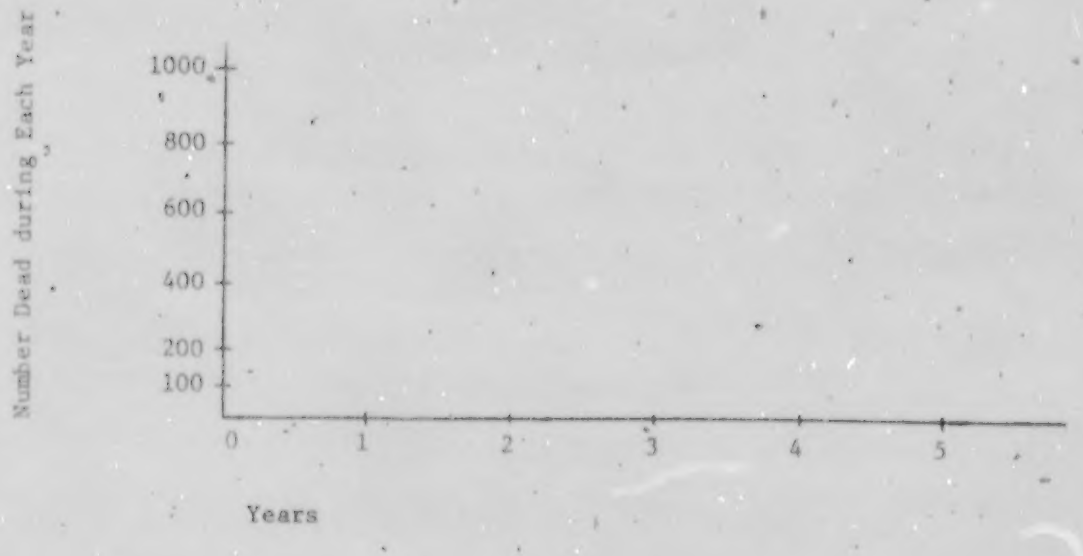
5) If the effective plan you found in 3) used a mosquito-control measure, run the program using exactly the same plan but without the mosquito-control measures. How do the costs compare? How do the results compare?

6) Run the program again using the best plan you found in 3), but this time eliminate the preventive-drug program instead of the mosquito-control measures. How do the costs compare? How do the results compare?

7) Using the three sets of axes following, make graphs that picture your results from 4), 5), and 6) above. Use the data from your printouts.

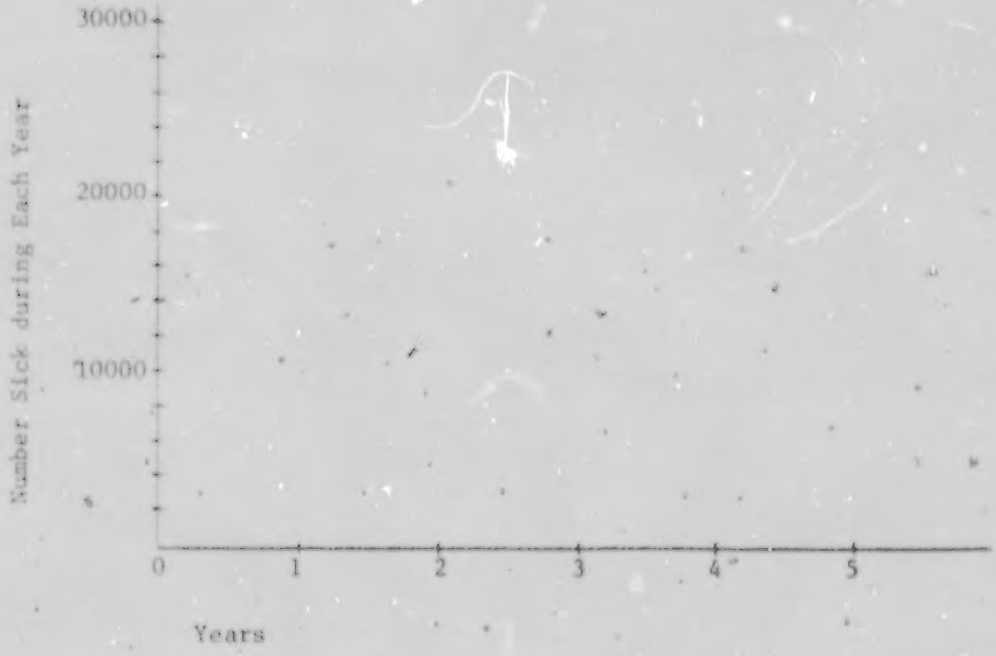
Graph Set #1: Results of Malaria Eradication Plan[from 4)]

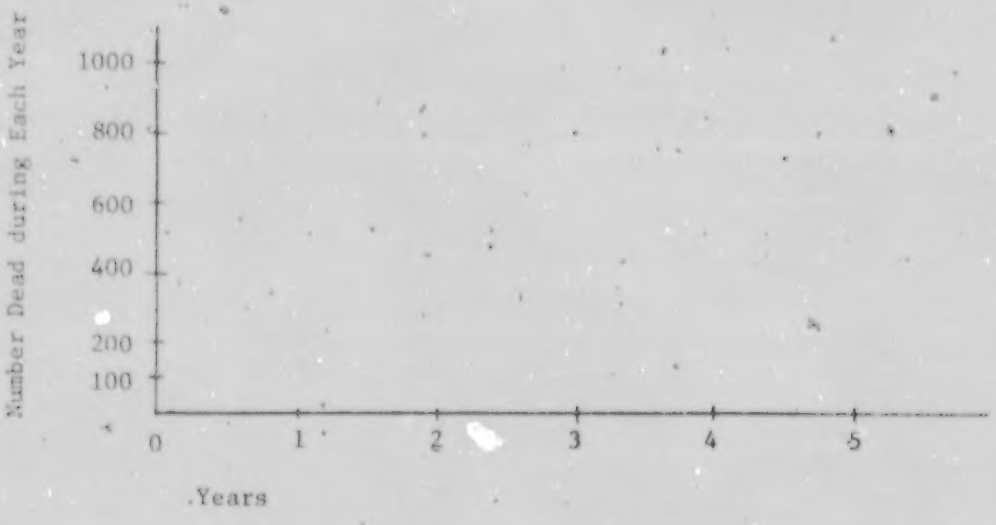




Total Cost of Program: $_____

Graph Set #2: Results of Malaria Eradication Plan
Without Mosquito Control [from 5)]





Total Cost of Program: $_____

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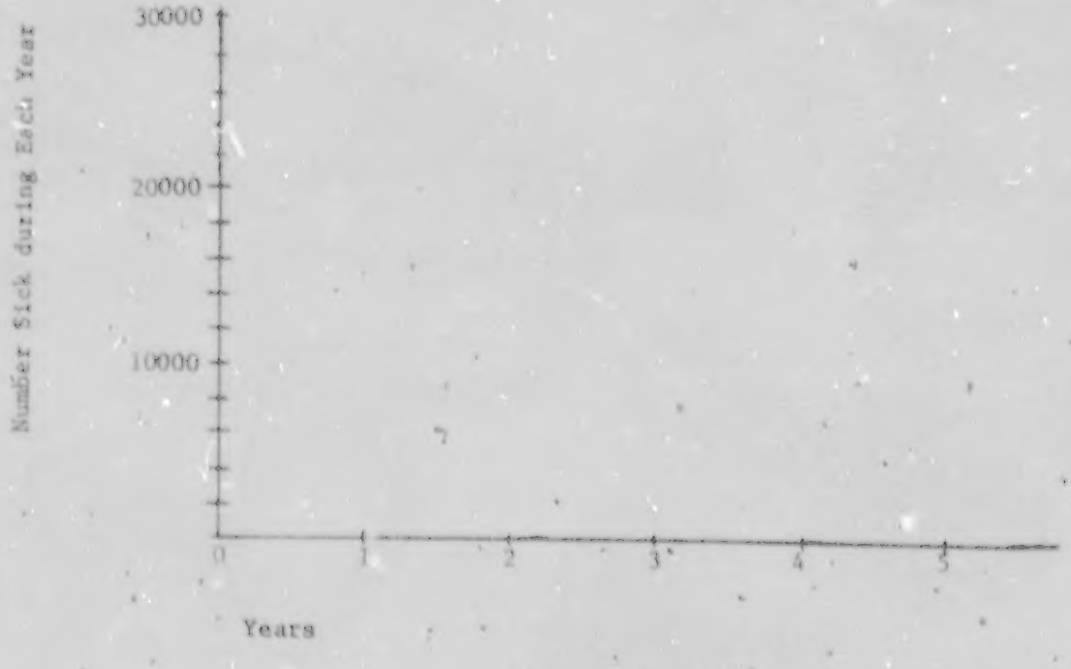
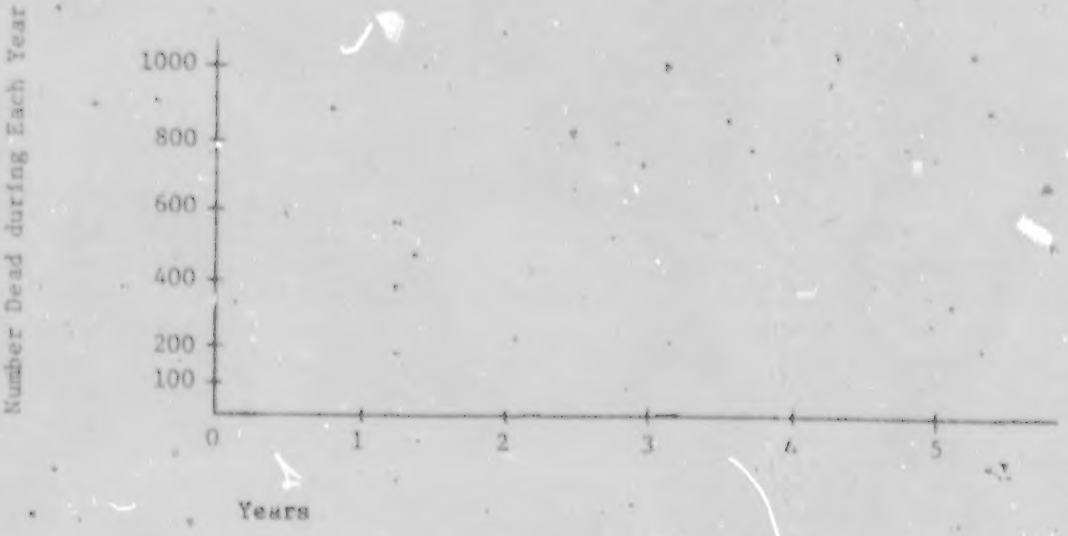
Graph Set #3: Results of Malaria Eradication Plan
without Preventive Drugs [from 6)]





Total Cost of Program: $_____

23

8) Ecologically speaking, DDT is an undesirable pesticide; however, the other two pesticides offered by MALAR are more expensive. A full treatment with malathion would cost about 3 times as much as a full treatment with DDT. A full treatment with propoxur would cost 8½ times as much as that with DDT. Use the MALAR program to find out if the use of alternative pesticides affects the flexibility of your control program given a limited budget. Describe your results.

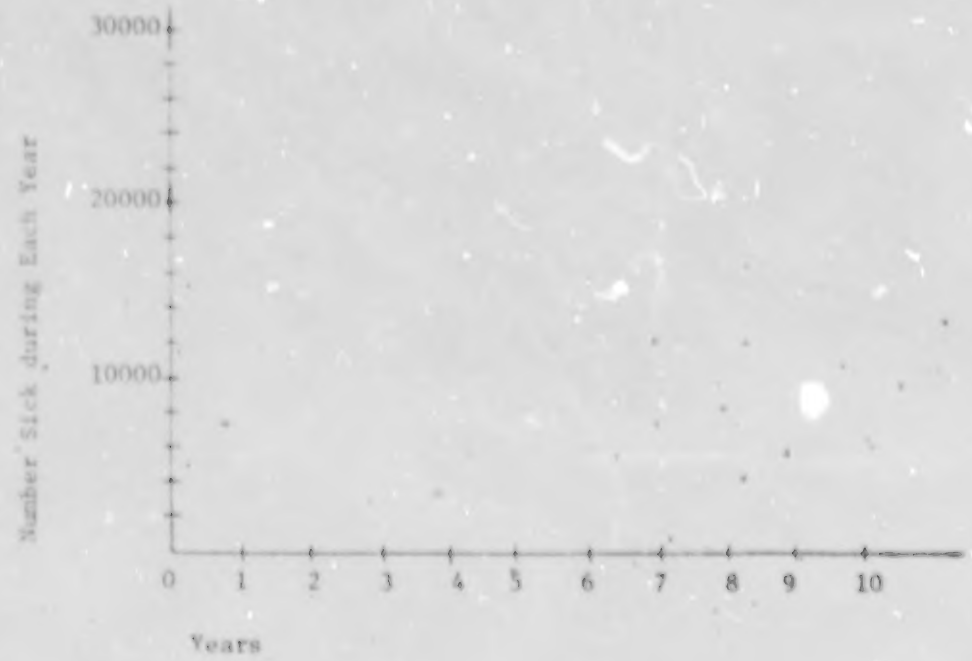
9) Did you experience any frustrations in working with the budget limitation? Describe them. Do you think your problems were realistic?

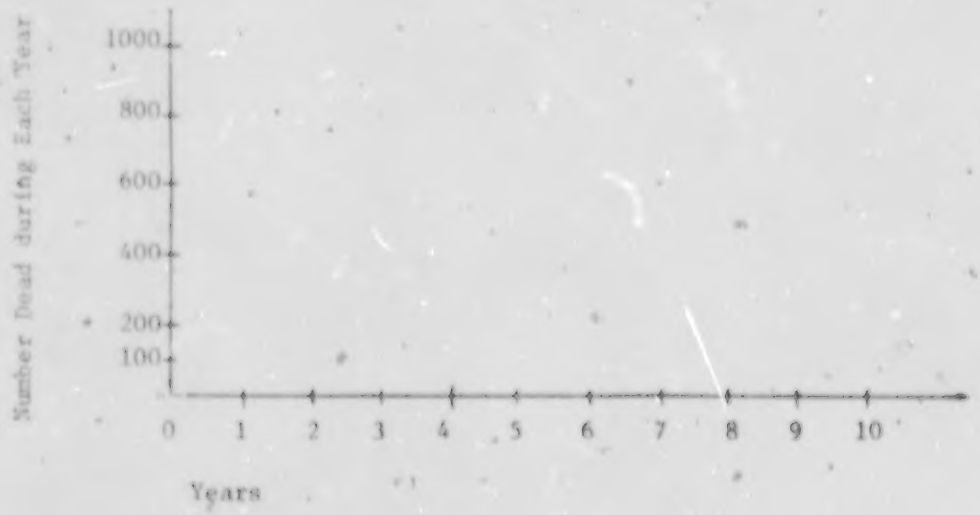
C. Exploration Exercises: Complications

In the previous exercise set, we assumed that your only problems were to stop the epidemic and stay within the budget. We made the assumptions that your money supply was steady; that you could get the drugs you wanted; that you had sufficient staff to carry out the eradication program; and many others. In this set of exercises, we are going to add another dimension of reality to your problem-solving by adding a few different conditions to the game.

1) Suppose that you were directing a ten-year malaria eradication program. You have $500,000 to spend during the first five years, and are supposed to have $500,000 for the next five years. However, during the sixth and seventh years, there is a severe economic depression and all your funds are cut off. You can do nothing at all during those two years, and your funds for the next three years are reduced to $300,000. Use MALAR and try to eradicate the epidemic in ten years under these conditions. Describe your results.

Make two graphs which depict the situation over the 10 years:





Total Cost of Program: $_____

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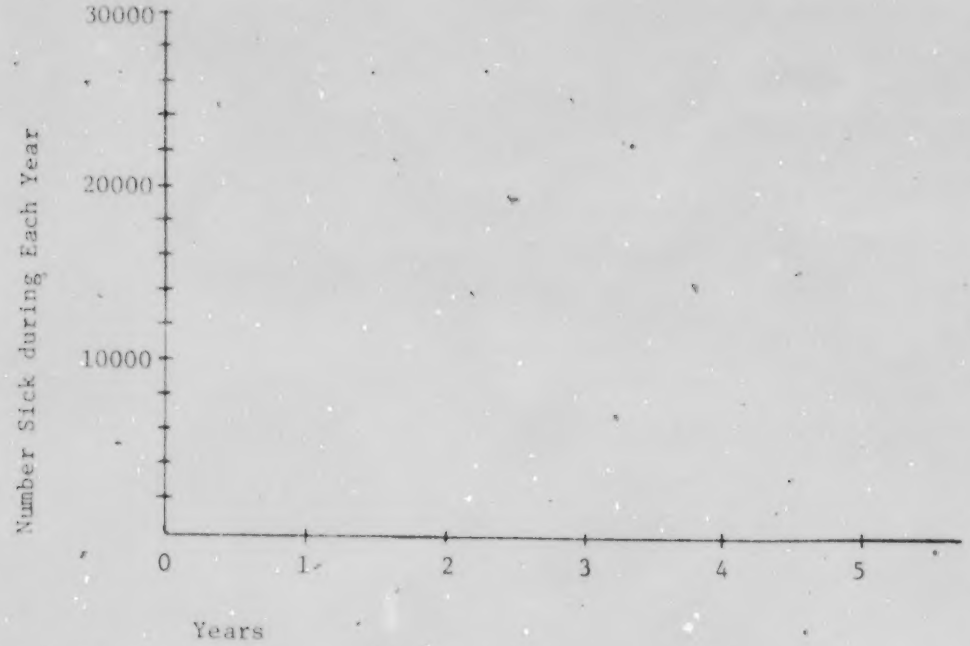
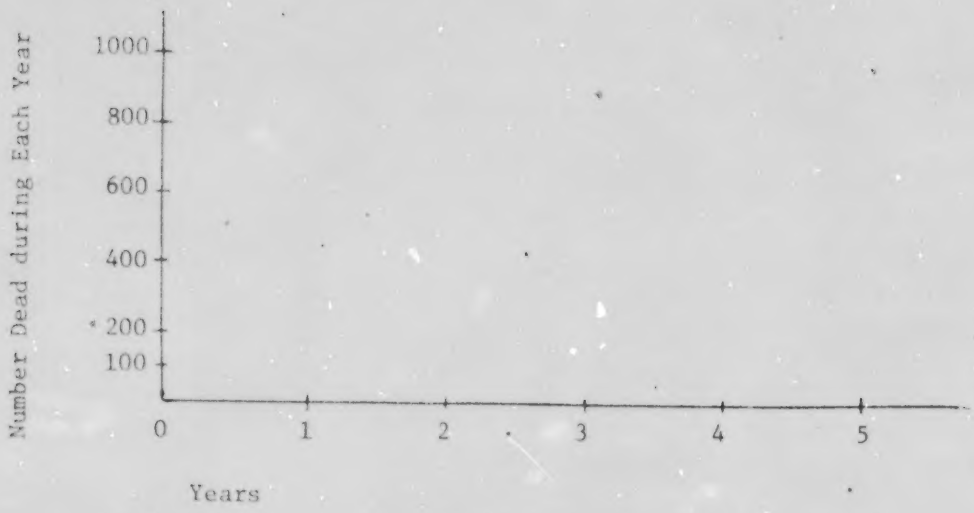
2) You have $500,000 to use for malaria eradication over a five-year period. Just before your third year into the plan, the United Nations bans the pesticide DDT, and puts a freeze on its use pending the results of a two-year study. This means that during the third and fourth years of your program, you cannot use DDT as a pesticide, and are unable to order alternative pesticide and equipment due to time considerations. At the end of the period, the ban is lifted to the extent that DDT can be used in emergency health programs. Thus, during the fifth year, you can use the pesticide DDT once again. Use MALAR and try to eradicate the epidemic in five years under these conditions. Describe your results.

Make two graphs to depict the situation over the five-year period:





Total Cost of Program: $_____

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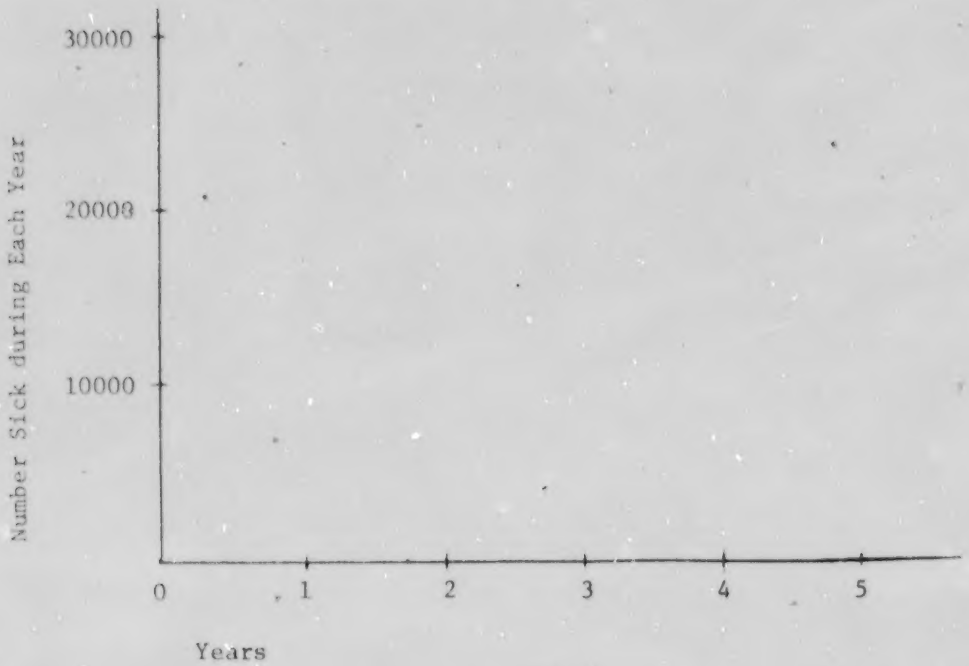
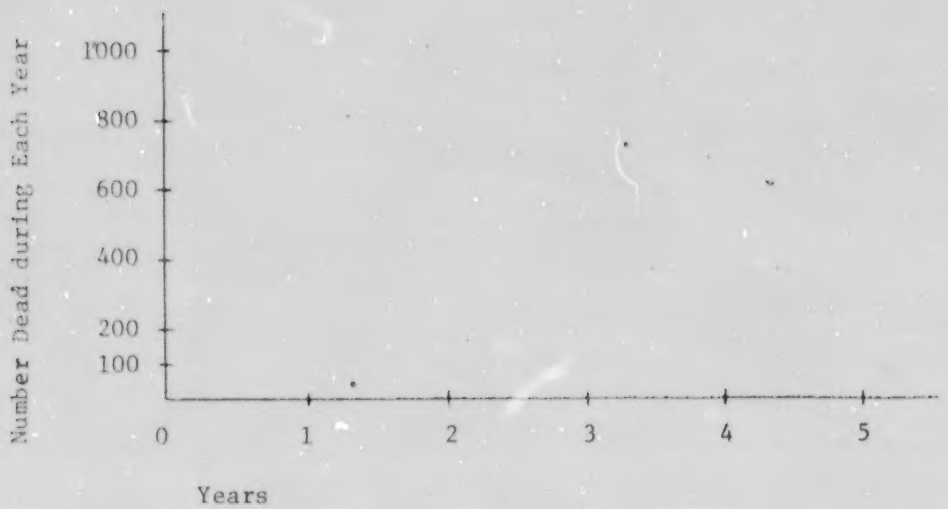
3) You are directing an eradication program with a budget of $500,000 for five years. After three years, a war breaks out and it becomes impossible for you to get any curative or preventive drugs for one whole year. At the beginning of the fifth year, your supply is resumed. Use MALAR and try to eradicate the epidemic in five years under these conditions. Describe your results.

Make two graphs which depict the situation over the five years.





Total Cost of Program: $_____

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PLAN OF ACTION

A TREATMENT PROGRAM	B COST PER UNIT	C NUMBER UNITS or PERCENT EFFICIENCY	D TOTAL YEARS IN EFFECT	E TOTAL COST
FIELD HOSPITALS	2000	X____hospitals/year	X____years	= $____
DRUGS FOR SICK	2	X____doses/year	X____years	= $____
MOSQUITOES Pesticides (choose one): a) DDT b) Malathion c) Propoxur	 750 2310 6375	X____% mosquitoes killed	X____years	= $____
PREVENTIVE DRUGS	0.72	X____doses/year	X____years	= $____

(Amount allowed = $500,000 if following budget)

Grand Total = $____

PLAN OF ACTION

A TREATMENT PROGRAM	B COST PER UNIT	C NUMBER UNITS or PERCENT EFFICIENCY	D TOTAL YEARS IN EFFECT	E TOTAL COST
FIELD HOSPITALS	2000	X____hospitals/year	X____years	= $____
DRUGS FOR SICK	2	X____doses/year	X____years	= $____
MOSQUITOES Pesticides (choose one): a) DDT b) Malathion c) Propoxur	750 2310 6375	X____% mosquitoes killed	X____years	= $____
PREVENTIVE DRUGS	0.72	X____doses/year	X____years	= $____

(Amount allowed = $500,000 if following budget)

Grand Total = $____

PLAN OF ACTION

A	B	C	D	E
TREATMENT PROGRAM_____	COST PER UNIT	NUMBER UNITS or PERCENT EFFICIENCY	TOTAL YEARS IN EFFECT	TOTAL COST
FIELD HOSPITALS_____	2000	X____hospitals/year	X____years	= $_____
DRUGS FOR SICK_____	2	X____doses/year	X____years	= $_____
MOSQUITOES Pesticides (choose one): a) DDT_____ b) Malathion_____ c) Propoxur_____	 750 2310 6375	X____% mosquitoes killed	X____years	= $_____
PREVENTIVE DRUGS_____	0.72	X____doses/year	X____years	= $_____

(Amount allowed = $500,000 if following budget)

Grand Total = $_____

TEACHER'S GUIDE $ 30

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HUNTINGTON II Simulation Program—MALAR

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TEACHER MANUAL

MALARIA ERADICATION PROGRAM

MALAR

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HUNTINGTON TWO COMPUTER PROJECT

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1 March 1973

The work of the Huntington Two Computer Project is partially supported by the National Science Foundation, Grant GW-5883.

MALAR

SECTION II - TEACHER MANUAL

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MALAR

TEACHER MANUAL

I. BASIC INFORMATION ABOUT THE UNIT

Subject Area: Biology, social studies, health, ecology

Specific Topic: Malaria and its eradication

Grade Level: 10 - 12

Coordinated Computer Programs: MALAR

Computer Language: BASIC

Special Language Features Used: RANDOMIZE, FNR

Abstract: A computer program which allows the user to attempt to control a malaria epidemic provides a context within which to study the biological, economic, social, political, and ecological aspects of a classic world health problem.

NOTE: FOR THOSE USING SMALLER COMPUTERS: START MALAR PAPER TAPE IN MIDDLE AFTER THE SECOND LEADER. PROGRAM SHOULD START AT 400 IF PROPERLY LOADED. YOU WILL BE MISSING INITIAL POPULATION DATA AND TREATMENT COST DATA SHOWN ON PAGE 3.

II. DESCRIPTION OF THE UNIT

This unit focuses on malaria eradication as a classic example of a world health problem. Although the materials in the unit consider the biological and medical aspects of the problem, they by no means stop there. The problem is put into economic, social, political, and ecological perspectives, and is treated as a representative case study of a health problem which involves a multiplicity of concerns for its solution.

The *TEACHER MANUAL* describes general strategies for successful use of the computer program, details a plan for use of the unit, and suggests several contexts in which it might be introduced. The *STUDENT MANUAL* provides a clear description of the computer program, and gives exploration exercises for use with the computer program. These exercises guide the student in exploring cost, effectiveness, and strategy with respect to a malaria eradication program. In addition, the *STUDENT MANUAL* helps the students learn to deal with contingency factors and to display and interpret their results in graphic form. The *RESOURCE MANUAL* includes an extensive section of background information about malaria and many related topics. It also treats health in general as an economic, ecologic, social, and political concern. The *RESOURCE MANUAL* includes a list of projects, an annotated bibliography of resources, and a complete description of the mathematical model used in the program.

III. DESCRIPTION OF THE PROGRAM

The program MALAR simulates the attack phase of a malaria eradication plan. It allows the user to attempt to eradicate malaria from a given area within five years. The user can try to do this with or without a budget limitation.

Be sure that the student knows he is working with the following conditions.

APPROX. POPULATION OF AREA: 100000

APPROX. NUMBER ILL WITH MALARIA: 25000

APPROX. NUMBER DEATHS/YEAR DUE TO MALARIA: 1000

GOAL: ERADICATE OR MINIMIZE THE MALARIA INCIDENCE IN THE AREA OVER A 5-YEAR PERIOD.

THE USER CAN MAKE USE OF A 4-TREATMENT METHOD, NAMELY:

1) To isolate in field hospitals those afflicted by malaria
2) To administer drugs to those who are ill
3) To use a pesticide to kill mosquitoes
4) To give preventive drugs to those still healthy

THESE ARE THE APPROXIMATE COSTS:

Field hospital of 20 beds: $2000 per year

Maximum malaria drug treatment: $2/year/person

Full anti-mosquito spray:

When using *DDT* - $ 75000
When using *Malathion* - $231000
When using *Propoxur* - $637500

Preventive drug effective 1 year: 72¢/person/year

(IF USING A BUDGET, YOU HAVE $500,000 TO WORK WITH.)

Each alternative treatment is offered, and then the user is allowed to specify the extent to which he wants to use each treatment method during the five-year period. After the user enters his decisions for a specific treatment method, the computer will print out the cost of that plan and the total amount of money allocated by the user to that point. If the program is being used with a budget restriction, the computer will print out the balance remaining in the budget. After the user has entered his decisions for all four types of treatment, the computer will tabulate the results of the user's five-year overall plan. It will specify for each year the number sick with malaria and the number of deaths caused by malaria. It will also print out the total amount spent over the five years, and if a budget restriction has been used, it will print the remaining balance. The user may then: 1) get an evaluation of the effectiveness of each part of his plan, and 2) continue with the problem for another five years, or 3) start over, or 4) stop the program.

To be considered successful, the user should reduce the total number of sick to below 1000 for a total of five consecutive years.

IV. NOTES ON RUNNING THE PROGRAM

The MALAR program is straightforward and simple to use. However, to prevent even slight confusion from arising, the following points should be mentioned.

1) When the user has finished entering all his decisions, the computer will print out a table that will show the results of his five-year plan. The first line in the table is printed with a "Ø" in the column headed "year." This simply refers to the time before the user began to implement his eradication plan. The other statistics in that line give the specific numbers of sick and dead at the time that the eradication plan was begun.

2) When the computer prints out the results of the five-year plan, the number of sick specified for any one year refers to the number sick during that year. The number of deaths printed refers to the actual number of deaths which occurred during that year. The number of people who actually were sick that year is usually greater than the number given in the printout, since some have usually received treatment.

In general, the best strategy to follow over a five-year period is to use both curative (hospitals and drugs for ill) measures and preventive (mosquito control and immunization) measures.

V. SAMPLE RUN

BUDGET; NO HOSPITALS: GOOD RESULTS

```
DO YOU REQUIRE INSTRUCTIONS FOR MALAR (1=YES, 0=NO) ?0
YOU MAY USE MALAR EITHER WITH A BUDGET (VERSION 1)
OR WITHOUT A BUDGET (VERSION 2). VERSION NUMBER ?1

YOUR OBJECTIVE IS TO MINIMIZE MALARIA FOR THE NEXT
5 YEARS, WITH A TOTAL FUND OF  500  THOUSAND DOLLARS

--------------------------------------------------  (HOSPITALS)

HOW MANY FIELD HOSPITALS DO YOU INTEND TO USE ?0

--------------------------------------------------  (DRUGS FOR SICK)

HOW MANY FULL TREATMENTS OF DRUGS
FOR THE ILL, SHOULD BE ORDERED PER YEAR ?7300

FOR THIS TREATMENT:
INDICATE YEARS TO BE USED BY TYPING, AFTER THE YEAR,
1=YES OR 0=NO
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 73000
THIS LEAVES A BALANCE OF  427000  DOLLARS

--------------------------------------------------  (MOSQUITOES)

WHAT PERCENTAGE OF MOSQUITOES DO YOU WANT TO ELIMINATE ?100
WHAT PESTICIDE WILL YOU USE
1=DDT       2=MALATHION       3=PROPOXUR
 ?1

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 375000
THIS LEAVES A BALANCE OF  52000  DOLLARS
```

```
------------------------------------------------   (PREVENTIVE DRUG

HOW MANY DOSES OF PREVENTIVE DRUGS, FOR THOSE
HEALTHY, DO YOU WANT TO ORDER PER YEAR ?10000

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 36000
THIS LEAVES A BALANCE OF  16000  DOLLARS


USING YOUR PLAN:
YEAR          NO. SICK       NO. DEATHS DUE TO MALARIA
----          --------       -------------------------
 0             24881          939
 1             692            3
 2             706            7
 3             707            7
 4             698            5
 5             703            6

OVER YOUR  5  YEAR TREATMENT PROGRAM
 28  DEATHS DUE TO MALARIA HAVE BEEN RECORDED

DO YOU WISH AN EVALUATION (1=YES, 0=NO) ?1


TOTAL COST  484000  DOLLARS
PROGRAM       COST          YEARS          EFFECTIVENESS (PCT.)
-------       ----          -----          --------------------
DRUG TREAT     73000         5              95
MOSQ SPRAY    375000         5              90
PREVENT DRUG   36000         5              6

SURPLUS ORDERING:
 13124  TREATMENTS OF DRUGS FOR SICK UNUSED
OF THESE  5997  DOSES ARE STILL USABLE

DO YOU WANT TO (1) TAKE THE NEXT FIVE YEARS
OR (2) START OVER  OR (3) END. TYPE NUMBER ?3


TIME:  2.93 SECS.

READY
```

VI. RATIONALE FOR THE UNIT

The MALAR unit provides a context within which to explore the economic, biological, political, and ecological ramifications of a classic example of a serious health problem. Often the problems of public health are viewed only as medical ones, when in fact they are also very much economic, political, and even ecological. A unit of study such as that suggested by MALAR can be of great assistance in helping students learn about, and gain an appreciation of these other factors related to health problems.

Many school programs are beginning to recognize the importance of the study of health at all levels and in the broad sense of the term. A unit like MALAR provides a novel, interesting core for a related unit of study. Since MALAR treats a classic health problem, it provides a springboard to considerations of other health problems.

At a more specific level, MALAR helps a student to learn something about epidemiology and the health problem of malaria. He can determine basic principles of dealing with an epidemic disease. The computer program allows the student to become the decision-maker in a situation involving public health, and requires him to balance economic considerations with biological and medical ones. Using the computer simulation, the student has an opportunity to explore a public health situation from new perspectives and at the same time to develop some important inquiry and problem-solving skills.

VII. SUGGESTED OBJECTIVES FOR THE UNIT

General Objectives

A. To convey a sense of the complexity of a health problem by allowing the student to explore economic, ecologic and other concerns as well as medical and biological factors.

B. To help students gain a sense of the various strategies which can be used to fight an epidemic and the relative costs and effectiveness of these strategies.

C. To provide students with some exposure to the areas of public health and epidemiology.

D. To allow the student to explore the consequences of banning DDT in malaria-control programs worldwide.

Specific Objectives

After completing this exercise, a student should be able to:

A. Briefly discuss the disease of malaria, including points such as:

1) how it is transmitted

2) the types of conditions under which it will appear

3) strategies for eradicating it

4) the status of the disease in the world today

B. Based on his experience with the MALAR computer program, discuss the effect of each of the following types of treatment programs on the disease epidemic:

1) field hospitals

2) drug treatments for the ill

3) mosquito control using pesticides

4) preventive medicine

C. Based on his experience with the MALAR computer program, discuss the most effective strategy he found for eradicating the disease when a) he had no financial restriction, and b) he had a financial restriction.

D. Discuss the four stages of a disease-eradication program:

1) preparatory phase

2) attack phase

3) consolidation phase

4) maintenance phase

Briefly describe the activities which are carried out during each phase.

E. Discuss some political, social, economic, and ecologic concerns related to health.

F. Briefly summarize the major arguments on both sides of the controversy over DDT.

VIII. PLAN FOR USING THE UNIT

A. Curricular Openings for This Exercise

The MALAR unit could be introduced at several different points in several different curriculum areas. In biology, the unit makes a nice accompaniment to Chapter 1 in the BSCS Yellow version, in which malaria is studied as an example of a biological problem. It would also be appropriate in biology when studies focus on ecology or epidemic diseases.

MALAR could also be integrated into a social studies unit which focuses upon health as a condition for social and economic growth, or upon the economic aspects of health maintenance. A study of ecological problems also provides an ideal setting for the use of MALAR, because it allows the student to explore the use of various pesticides in a critical emergency situation.

In addition, MALAR would fit in nicely at many points in a health curriculum. It would enhance any study of world health problems, or the study of health as a part of a total environmental system.

MALAR is also a good computer simulation which could serve as an introduction to modeling and simulation.

B. Preparatory Activities

Prior to actually using the MALAR program, the students should acquire some background information about such topics as health, epidemic control, malaria, and pesticides. The *RESOURCE MANUAL* included with this unit comprises a section of background material which should be sufficient. It is written for the suudent and could be given directly to him for use as a text, or it could be used by the teacher to prepare several class sessions which would deal with the topics involved. Of course, there are many different ways to approach this preliminary activity. Students could be given research assignments on the various topics and the information presented at a class "symposium." In any case, this section of the *RESOURCE MANUAL*

does provide some idea of the kinds of information that are important for a student to have in order to approach the MALAR program with some base of knowledge.

In addition, the students should fully understand that they are using a simulation which was designed under a specific set of assumptions. They should know what those assumptions are and should have an opportunity to discuss them. Also, the students should understand how MALAR works, what they will be expected to do with the program, and what the program will do for them.

C. Using the Program

Students can use the MALAR program individually or in groups. The *STUDENT MANUAL* suggests several investigations which students can make using MALAR. These relate to the effectiveness of various eradication strategies, the financial considerations of health maintenance, and contingent problems. General approaches to the exercises in the *STUDENT MANUAL* are discussed under "TEACHER INTRODUCTION TO THE *STUDENT MANUAL*."

D. Follow-up Questions

Once the students have worked with the MALAR program, you may want to spend one or two class sessions discussing results. In addition to discussing the questions in the *STUDENT MANUAL*, it might be useful to explore the ideas suggested by the following questions.

1) What malaria eradication strategies did you find to be most successful?

2) Even though you might employ a prevention strategy in full strength, the actual effectiveness of that treatment option was always lower than 100%. Can you think of some reasons why the actual effectiveness would be less than 100% for each of the following:

   hospital bed program ?

   curative drug program ?

   mosquito control program ?

   immunization program ?

3) What are some economic concerns involved in solving world health problems? political concerns? social concerns? ecological concerns?

4) In your opinion, how realistic do you think the results were that you got using this simulation?

5) Who do you think should assume the costs of eradicating malaria or any other epidemic disease on a worldwide basis?

6) Who should decide whether an eradication program should be implemented in a country?

7) What happens if you cut back on precautionary measures before the epidemic is completely quelled?

8) In a malaria eradication program, if you are restricted financially so that you can only order enough preventive drug doses for half the population, how would you decide who would get the drug and who would not?

9) What kinds of information would you need to obtain during the preparatory phase of an eradication program if you were a public health official?

IX. TEACHER INTRODUCTION TO THE *STUDENT MANUAL*

The *STUDENT MANUAL* in this unit is designed as a guide for using the MALAR program. It systematically poses questions which involve the student in determining the effectiveness of various treatment options, the relative costs of the options, and some strategies that will successfully eradicate the epidemic. It also construes some contingency situations for the student to impose on the playing of the game which make winning the game a more difficult task. The exercises are not very rigidly constructed; rather they present thought-provoking questions to the student which require him to devise his own approaches to finding answers. However, they are intended to help the student organize his work with the program so that he is consciously doing more than merely making several random plays of the game. Taken as a whole, the questions suggested ensure that the student will consider relevant, important ideas while he is using the program.

REASON FOR USING THE *PLAN OF ACTION* CHART

The *PLAN OF ACTION* chart allows the student to think ahead and plan his overall control program. If the student selects to work within a budget when trying to combat malaria, he must stay within the limits of that budget. The *PLAN OF ACTION* chart permits him to see if his control program will fit within budget limits. If he overspends, he can make the necessary adjustments before going to the machine. Use of the chart helps maximize the efficiency of use time of the machine and the student. As a further check, if the student miscalculates and spends more than he should, the computer will tell him so. Three additional *PLAN OF ACTION* charts are included at the back of the *STUDENT MANUAL*.

PLAN OF ACTION

A	B	C	D	E
TREATMENT PROGRAM_____	COST PER UNIT	NUMBER UNITS or PERCENT EFFICIENCY	TOTAL YEARS IN EFFECT	TOTAL COST
FIELD HOSPITALS_____	2000	X_____hospitals/year	X_____years	= $_____
DRUGS FOR SICK_____	2	X_____doses/year	X_____years	= $_____
MOSQUITOES Pesticides (choose one): a) DDT_____ b) Malathion_____ c) Propoxur_____	 750 2310 6375	X_____% mosquitoes killed	X_____years	= $_____
PREVENTIVE DRUGS_____	0.72	X_____doses/year	X_____years	= $_____

(Amount allowed = $500,000 if following budget)

Grand Total = $_____

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Resource Handbook	.50
Program Paper Tape	1.00

RESOURCE MANUAL

MALARIA ERADICATION PROGRAM

MALAR

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1 March 1973

The work of the Huntington Two Computer Project is partially supported by the National Science Foundation, Grant GW-5883.

MALAR

RESOURCE MANUAL

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I. BACKGROUND MATERIALS

Health as a Quality of Life

Most American young people enjoy reasonably good health. Good health seems to be one of those things that we take for granted, and it is difficult to realize that much of the world lives constantly under the threat of death and disease. Health can really be thought of as one quality of life which is necessary for social, economic, and moral growth.

Have you ever thought about the economic consequences of a country in poor health? If the people of a nation are sickly, their vitality is low. They cannot work, and the economy of the country suffers. Many poverty areas of the world get caught in a vicious cycle. A low production level caused by illness results in substandard incomes. When people do not have money, they cannot afford adequate housing and medical care. Often they suffer from poor nutrition. These factors can lead to an even higher rate of disease, which in turn saps more of the energy of the people and still more of them become unable to work. You can see then how many underdeveloped countries, as well as some areas in well-developed countries, can get caught in this downward economic spiral. Poor health in a country can have many other effects as well on the social and even political life of the country.

In this unit, you will concentrate on malaria as a classic example of a world health problem that has caused many deaths and has brought on severe economic and social problems in many parts of the world. When we study a disease like malaria as it affects a *community* rather than as it affects an individual, we are stepping into the branch of science called *epidemiology* (ep´ i dē´ mē ol ə jĭ). Epidemiology is concerned with those factors which influence the onset, spread, and eradication of a disease as it affects a group of people.

You will use this particular problem to help indicate that financial considerations are often important in solving medical and biological problems.

Malaria

Malaria is a disease that is caused by any one of four different kinds of one-celled animals called *protozoans*. These four types occur in different parts of the world and cause different types of infection. They are:

1) *Plasmodium falciparum*, which occurs primarily in the very warm parts of the world and causes the most severe and dangerous form of malaria.

2) *Plasmodium malariae*, which is less common, but causes a more persistent infection.

3) *Plasmodium ovale*, which is primarily found on the west African coast and usually causes milder forms of malaria.

4) *Plasmodium vivax*, which is widely distributed in the temperate and tropical parts of the world, and is the main *Plasmodium* in South and Central America.

When the blood cells of human beings are infected by these protozoans, male and female cells of the parasite develop over an average period of 10-14 days after infection. The time varies with the species of Plasmodium involved. The developmental process stops there in the human. If he is bitten by a female of a certain species of mosquito, call the *Anopheles* mosquito, the mosquito will suck up some of his blood cells containing the male and female parasite protozoans. Once the parasite protozoans are in the mosquito's stomach, they mate. In about 10-14 days, they release tiny bodies called *sporozoites*, which move to the salivary glands and the mouth parts of the mosquito. When the mosquito bites another person, it injects saliva containing the sporozoites into its victim. After undergoing an asexual life cycle in the liver, heart and/or brain, they reenter the red blood cells to burst, triggering off the symptoms of malaria. The chain of infection, then, goes from man to mosquito to man.

The infection can spread at startling rates. One person alone could conceivably infect 800 mosquitoes, who in turn (taking into account their death rate and life cycle) could distribute up to 1120 infections! Of course, the actual number of resulting malaria cases might be lower than 1120 because some of the infections may be given to individuals who already have the disease, or because some of the mosquitoes infected may already have been carriers. Nonetheless, you can see how rapidly the infection could spread. The object of disease control is to keep the number of infections decreasing until the disease disappears.

Let us take a close-up look at this carrier of malaria, the mosquito.

Mosquitoes

The mosquito is a small, fragile insect with a slender body, one pair of narrow wings, and three pairs of long, slender legs. They vary in length

from 1/16 inch to 1/2 inch. Only the female of the species bites man. They feed on his blood by means of a long "beak," called a *proboscis*. The male mosquitoes feed on plant nectar and juices. Some *Anopheles* mosquitoes bite only animals; others bite humans.

The life cycle of the mosquito has four major stages. It develops from egg to larva to pupa to adult. During the first three stages, the mosquito must have water in order to develop satisfactorily. The time required for development from egg to adult varies from 10 days to 7 months, depending upon the environmental conditions. Thus, in some areas, mosquitoes have only one generation a year, while in others, they have four or more.

Most mosquitoes of the Anopheles type (called anophelines) are short-lived. After they emerge as adults, there is a high death rate for a day or two. If a mosquito survives, it is not so susceptible to death by natural causes for the next two or three months. Finally, after that time, death is caused by old age.

Many factors about the mosquito influence both the spread and the intensity of the infection. The biting habits of the mosquito, the intensity of the infection in the mosquito, and the time necessary for the malarial parasites to develop in the stomach of the mosquito are all important.

Once you understand that the mosquito plays a key part in the transmission of malaria, it will be easy for you to guess that the spread of the infection in a geographic area is greatly influenced by the environmental conditions. Temperature, rainfall, and humidity determine where malaria is most likely to occur. Because water is necessary for the mosquito to develop, those places which are warm, moist, and have standing water that stagnates provide good breeding conditions for the mosquito. For example, many areas of Central and South America, and Central and South Africa, have a lot of trouble with malaria. In fact, the very name "malaria" comes from the Italian words meaning "bad air" because the disease was associated with the bad-smelling air that often occurs around swamps. Temperatures lower than 57°F. or higher than 90°F. are not conducive to the breeding and development of the mosquito. Heavy rainfall, of course, would provide many good, wet breeding places for mosquitoes, and, in some areas, the seasonal outbreaks of malaria are synchronized with the rainy season.

Sometimes good breeding conditions for mosquitoes can be inadvertently created by man. *SCIENTIFIC AMERICAN* (May 1972) carried an interesting article about the effects of the massive bombings that have occurred in Indochina. One effect of the massive "cratering" of the terrain in this area has been that many of the craters have penetrated the water table and have remained filled with water during most of the year. These craters have become suitable breeding grounds for mosquitoes, and the danger of malaria to the population in the area has been greatly increased. Military authorities have reported that malaria has spread to areas where it had not previously occurred, and the disease has been causing increasing concern in Indochina.

Treatment of Malaria

Once the disease has been contracted, with drug treatments the victim is usually kept up to one week in the hospital. The first few days he suffers severe attacks of chills and fever, often accompanied by severe sweating, nausea, and weakness or anemia. In treating malaria victims, doctors use drugs which will destroy the malarial parasites in the blood. For centuries, quinine was used to combat the disease.

As far back as 1632, after the conquest of Peru, explorers took the bark of the cinchona tree back to Europe. It was used in the first known effective remedy for malaria. However, it was not until 200 years later that it was discovered that the active ingredient in the bark was the bitter white quinine crystals.

Quinine acts by interfering with the growth and reproduction of the malarial parasites in the red blood cells. Very quickly, after the quinine is administered, the malarial parasites disappear from the blood, and the symptoms of malaria cease. However, quinine only acts on those parasites present in the red blood cells. If malaria parasites exist elsewhere in the patient's body, they may invade the blood cells after the quinine treatment has stopped, and cause a relapse. For many years, scientists tried to find other antimalarial drugs which would be more effective than quinine. The search intensified when, during World War II, the Allies' supply of East Indian quinine was cut off. Several drugs were developed which almost completely replaced quinine. Some of these, like chloroquine and chlorguanide are more effective than quinine in suppressing the symptoms of malaria. Others such as primaquine, have the advantage that they attack all the malarial parasites, rather than just those in the blood cells, and hence can produce complete cures. All these newer drugs also have the advantage that they can be completely synthesized in the laboratory.

However, during the 1960's, it was found that several strains of certain malarial parasites had developed resistance to the synthetic drugs. The use of quinine had to be resumed in certain areas of the world where these strains of parasites occurred, despite the undesirable side effects which can occur when massive doses of quinine are given. Sometimes impairment of sight or hearing or skin rashes and digestive difficulty can result. Scientists continue to search for a better antimalarial drug.

Prevention of Malaria

A malaria-eradication program is approached in four phases, which are described below.

1) *Preparatory* phase. During this time, geographical surveys are made to determine the extent of the problem, and planning for an eradication program is done. Personnel are trained, and the physical facilities are set up. In addition, studies are done to get data on the health state of the area.

2) *Attack* phase. Intensive action is taken during this time to eliminate the carrier mosquitoes. Indoor insecticide sprayings are normally done, and an immunization program is begun. Personnel try to track down all cases of malaria and treat them, and they try to determine the original source of infection for each case. This phase usually lasts four years or longer. When the incidence of the disease is low enough, the program proceeds to the next phase.

3) *Consolidation* phase. The major activity during this phase is intensive surveillance on all cases of malaria. Radical treatment is given to all those who become ill, immunization programs are carried out immediately, and efforts are made to locate and eliminate the source of the infection. Also during this phase, personnel are trained to take over the program when it enters the next phase.

4) *Maintenance* phase. Once the disease has been wiped out, the program enters the maintenance phase. During this time, the health team that has been organized keeps a close watch on the area and deals quickly and radically with any threat of a recurrence of the disease.

In addition to treating those who become ill with malaria, two other measures are taken during the *attack* phase. First, the mosquitoes which transmit the disease (also called vectors) must be attacked. Secondly, an immunization program must be carried out to prevent the spread of the disease.

There are several methods available for eliminating mosquitoes. Some are more effective than others. Since 1962, the pesticide DDT (dichlorodiphenyl-trichloroethane) has been used widely on a world basis to eliminate the malaria-bearing Anopheles mosquito. Because of the effectiveness of DDT, more than a billion people now live in areas which are free from the threat of malaria. In spite of this, the use of DDT has become a hotly debated issue. Many people think there is evidence to show that extensive use of DDT poses a real threat to the long-term health of the human race. Let us examine this chemical in more detail to see why.

DDT

DDT has many advantages as a pesticide. It is highly poisonous to insects, but appears to be relatively harmless, at least in the short run to mammals. DDT is not very expensive, which makes it economically desirable, and it is a chemical which is available as a dust, which makes it easy to apply. Mosquitoes that rest on surfaces which have been sprayed with DDT absorb a lethal dose of the chemical. When spread on water surfaces, DDT

will kill the mosquito larvae. DDT has been used more liberally than any other pesticide. In fact, it has been used so freely that it has been spread over the entire earth. DDT has been carried by wind and water, so that traces of it can now be found in the penguin of Antarctica.

One major problem with DDT is that it accumulates. It is a very stable chemical, and in many situations takes years to break down into its components. If even a single application of DDT is made in a forest area, it will be picked up by the animals in the forest for ten years. Not only does DDT accumulate, but it concentrates in living tissue. Even though the proportion of DDT in a body of water, say, may be infinitesimally small, a tiny animal living in the water will continue collecting the DDT from the water. If it becomes sufficiently concentrated in his body, the animal could be destroyed by it.

In 1972, the federal government officially banned the use of DDT except in the event of an emergency like a malaria epidemic or a major crop infestation. But the controversy still rages. Those who oppose the use of DDT, point to its effects on some animals, and claim that it is only a matter of time before analogous effects are felt by humans. In some species of birds, for example, DDT appears to interfere with their ability to handle calcium. As a result, these birds lay extremely thin-shelled eggs which do not survive to hatching. Those who favor the use of DDT, reply that it is not necessarily valid to generalize from animals to men, and that the evidence is not extensive enough to support the theory that DDT is even harmful to animals. This debate is an interesting one which you may choose to explore during the course of this unit.

The control of mosquitoes by the use of insecticides has become more difficult in recent years due to the development of a resistance to insecticides on the part of the mosquito. There has been some experimentation with insecticides other than DDT and other methods of mosquito control; but, so far, none of these has proved as easy and effective as DDT. An organic compound called *malathion* has been tried as an insecticide. Although it is ecologically more desirable, malathion is far more expensive than DDT.

Several natural methods of mosquito control have also been researched. One procedure tried was introducing a surface-feeding minnow, a natural enemy of the mosquito, into the mosquito's breeding areas. The minnows eat the mosquito larvae, and thus reduce the mosquito population. However, it was found that the minnows simply couldn't consume enough to reduce the mosquito population in heavily infested areas. Another procedure which has been tried is water control. Experiments have been done with increasing the salt content of standing water near a seaside by the use of tide gates, raising and lowering the water levels at strategic times to induce drying out of the larvae, and eliminating standing water by draining. Attempts have also been made to make natural breeding places undesirable to the mosquito by eliminating protruding vegetation and debris from the area. Still another method of mosquito control is that of releasing sterile male

mosquitoes into the mosquito population. The theory is that the sterile males will mate as usual with the females, but they will produce no new offspring. However, these experiments have not been as successful as predicted, because the females do not mate as predicted with the sterile males, and the reduction in population is not significant.

Although these natural methods of control are more ecologically appealing, they have not, as yet, been able to provide the control necessary for an effective malaria-eradication program. The search goes on for a more effective natural method of control. When you work with the computer program in this unit, the only method of mosquito control available to you will be the use of pesticides.

Immunization Programs

In addition to mosquito-control practices, any effort to eliminate malaria must include the use of preventive drugs. If a good portion of the population can be protected against malaria, the better the chances are that the disease can be controlled. The antimalarial drugs mentioned previously can be administered to persons who do not have the disease. In some cases the drugs prevent the disease by suppressing the development of the symptoms of the disease. In other cases, the drugs suppress the symptoms but allow a low-grade infection to occur, which helps the individual develop an immunity.

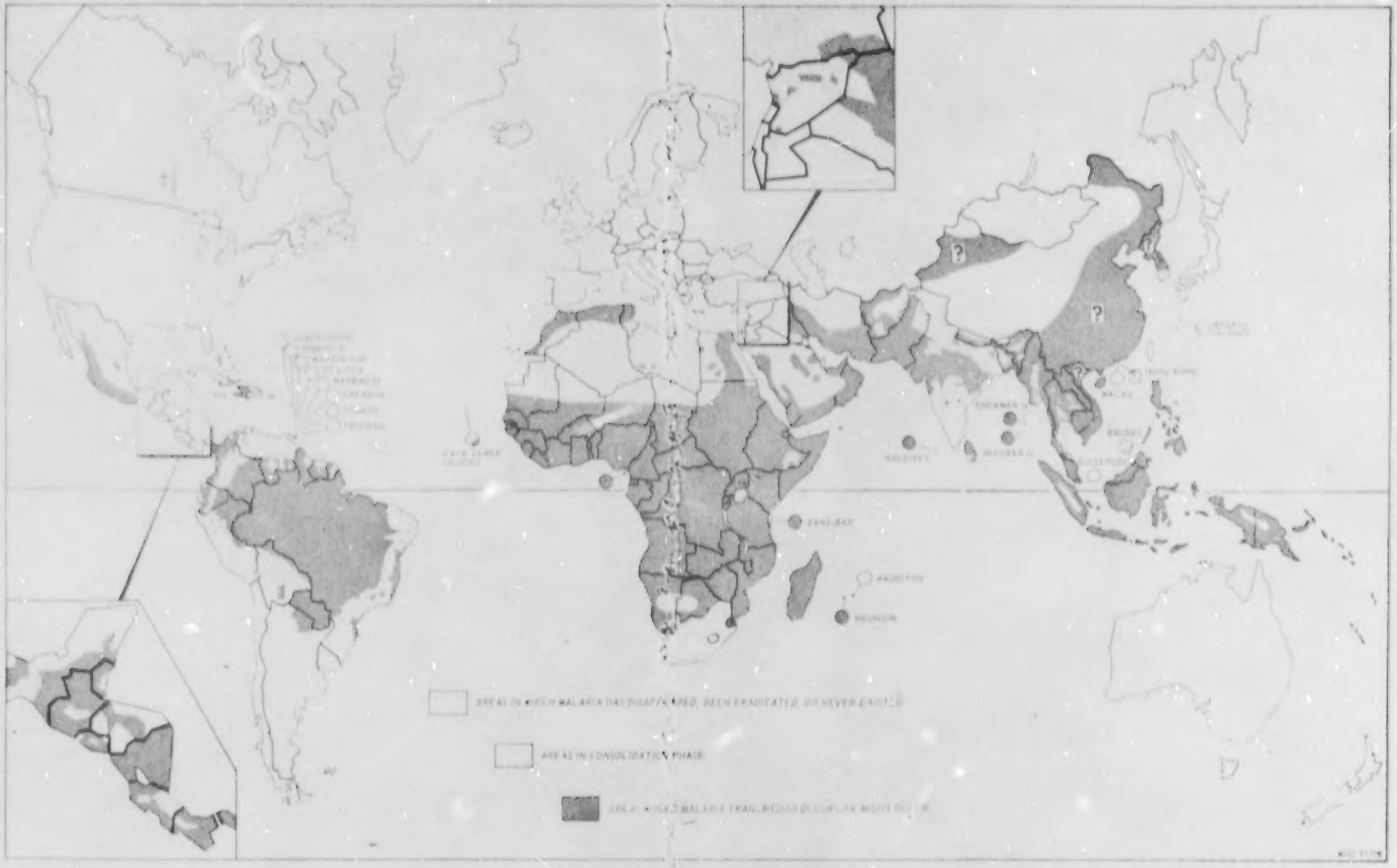
Status of Malaria Today

Malaria has been one of the biggest world health problems for many years. As of September 30, 1970, of the estimated 1802 million people living in the originally malarious areas (excluding China, North Korea, and North Vietnam), 1340 million (or 74%) of these were in areas where malaria had been eradicated or where an eradication program was in progress. The map in Figure 1 depicts this world situation. (Map is report as of June 30, 1969.) Figure 2 shows the pattern of malaria occurrence in the United States. Note the sharp increase of the disease related to the return of the Vietnam veterans.

Health and Economics

When thinking about health and health problems, most people oversimplify the matter. Health is not merely a matter of medicine and biology. Health is really very closely tied up with many other kinds of concerns. It relates to economic, ecologic, social and political considerations. We will begin to survey some of these relationships here in order to prompt you to try to imagine the implications of the decisions you make when you actually work with the computer program *MALAR*.

If you gave it a moment's thought, it would probably be quite obvious to you that the physical health of a nation bears a strong relationship to its economic health. Earlier in these materials, we spoke of the



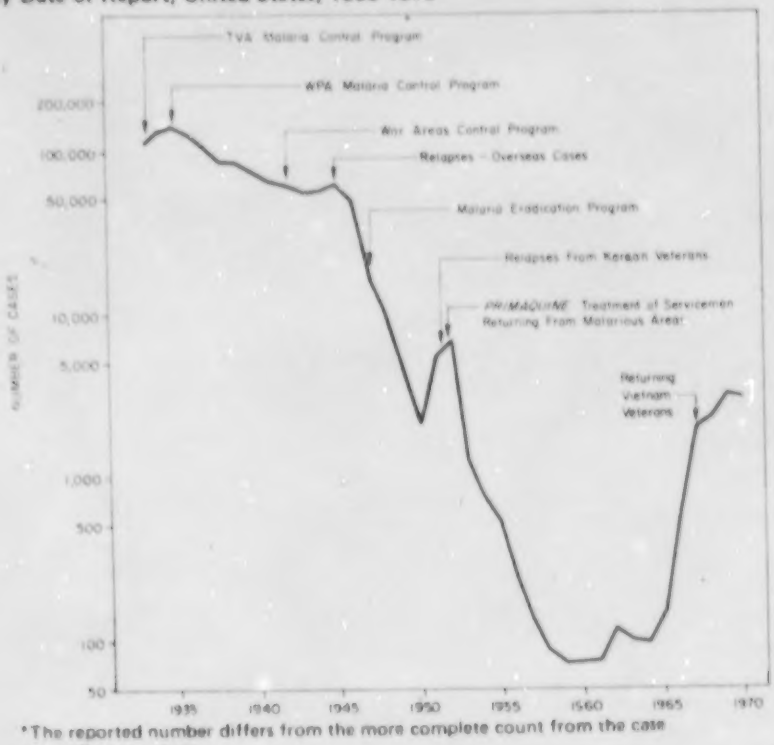
65

Figure 1. Malaria Situation - June 30, 1969

(Source: *WHO CHRONICLE*, Vol.24, No.9, September 1970, p.398)

66

MALARIA – Cases* by Date of Report, United States, 1933-1970



*The reported number differs from the more complete count from the case surveillance system.

MALARIA – Military and Civilian Cases, United States, 1959-1970, Surveillance Program

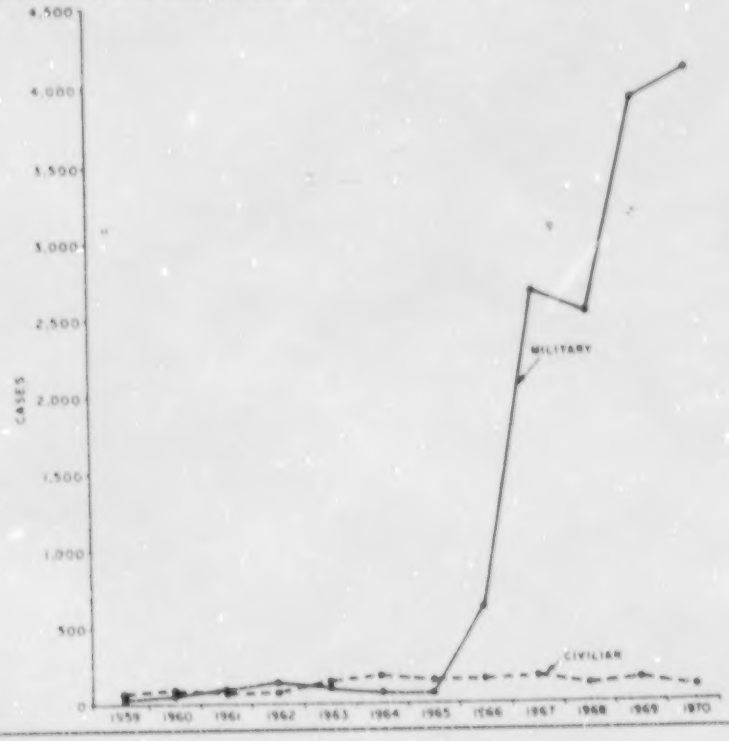


Figure 2. Pattern of Malaria Occurrence in the United States
(Source: *MORBIDITY AND MORTALITY.* U.S.Department of H.E.W., Center for Disease Control, Weekly Report, Vol.19, No.53, August 1971)

vicious cycle that can catch poor nations and doom them to economic disaster. The World Health Organization cites several examples of countries in which disease -- especially malaria -- had drained the economy, and where the eradication of the disease had saved it. In Afghanistan, for example, one million peasants lived under the constant threat of malaria. Some of that nation's most fertile land could not be cultivated because of the ravages of the disease. Malaria had caused a loss of $20 million in earnings. In Thailand, fifty million agricultural work days were lost each year due to malaria. This amounted to an economic loss of nearly $15 million. In Mexico, the eradication of the disease has increased productivity 100%. But there is another related problem that must also be considered. Available funds in many countries are normally fully committed, and it is rarely possible to find money to support the malaria-eradication program. Even if money is available, the program is sometimes not sufficiently well planned, and contingencies or possible difficulties are not taken into account. The result is that the eradication program does not have its full effect, and serious setbacks may occur.

You can see, then, that the relationship between the economy of a country and its health is a two-way relationship. The economy affects the health, and the health affects the economy. You may want to explore some possible ways of breaking this cycle during your study of this unit.

Health and Ecology

In the twentieth century, it is next to impossible to consider health without considering its relationship to the ecology of the world.

Earlier in these materials, we talked about the controversy over the use of DDT as an aid to malaria eradication. This is a serious problem for both the ecologist and the public health expert. DDT has freed millions of men from the threat of malaria, and yet some believe that in the long run, man has been harmed rather than helped. On this issue, you are the one who must give the evidence a fair weighing, and then, decide for yourself.

Still another ecologic concern arises with respect to the eradication of any disease. When a disease like malaria is controlled or eradicated from an area, the result is that the death rate of the population is greatly lowered, but the birth rate either remains the same or increases, due to the elimination of the disease. This situation, of course, leads to a real growth in the population. In Ceylon, for example, the control of malaria reduced the death rate by half and doubled the life expectancy, resulting in a rate of population increase that threatens to nullify the benefits obtained unless the birth rate is controlled. Sudden uninhibited population growth in a country like that can actually lead to a lower standard of living, for the population can easily demand more food, shelter and jobs than the country can supply. Some ecologists believe that disease

is a natural method of population control and that interfering with the normal course of events is undesirable. Others believe that science and technology can satisfy the needs of the people until they ultimately can bring birth rates and death rates into balance in a relatively "disease-free" world. This debate is another ecological one that would be interesting for you to probe.

Social and Political Concerns Related to Health

Today we live in a world that has become smaller and smaller. Jet travel allows a person to get virtually anywhere in the world within a matter of hours. Because the world has in effect become more accessible, social, political, and economic patterns and relationships have changed drastically, and we are better able to speak truly of the "world community." Our interest in world health has therefore been stimulated by political and social concerns as well as humanitarian ones. For example, whereas 50 years ago the health of the South Vietnamese people may not have influenced the United States in any significant way, it became a vital concern when, in the early 1970's, the U. S. attempted to "Vietnamize" the war there. If the South Vietnamese as a people were ill, the effort could not have been made. Again, whereas 75 years ago, the health of the western European nations may not have directly affected the health of Americans, today we are very concerned because thousands of Americans travel to those nations and return to the U. S. With the possibilities of travel in China and the U.S.S.R. being opened up, we must also be concerned with health in those countries. In fact, the world has become such that we must be concerned with world health if we are to be solicitous about our personal health. The World Health Organization (WHO) has concluded that insect vectors of disease, including *Anopheles* mosquitoes, can enter modern aircraft and survive long flights and that the spread of malaria in the world and the success or failure of its prevention and control can also be influenced by air transport.

We have discussed previously how a nation's health can affect its economy. You can probably see that health also has consequences on the political status of the country. If a nation is ill, it is weak and can be at the mercy of stronger, healthier nations. In the event of war, you can easily imagine how important the factor health is to a country.

The world situation in turn can have a significant effect on the health of the world. For example, during World War II, when Japan entered the war, the supply of quinine which the Allies had been using to treat malaria was cut off. If it had not been for the synthetic chemical compounds that were developed at that time, the course of events might have been changed. The drug *quinacrine* indeed helped the Allies achieve victories in Africa, southeast Asia, and the Far East because it was able to ward off malaria and a subsequent troop depletion.

In addition, the political situation in a nation can have a great effect on the health of the nation. For example, an effective malaria-eradication campaign depends on full government cooperation. Funds must be allocated for the program, and then the administrative staff for the program must be able to depend on the government officials in order to carry out the program efficiently and on schedule.

Thus, once again we have a two-way relationship. The political and social concerns of a country affect its health, and the health of the country affects it politically and socially.

ORGANIZATIONS DEDICATED TO THE CAUSE OF WORLD HEALTH

WHO

There are several organizations which are dedicated to pursuing the goal of world health. The World Health Organization (WHO) was formed as a specialized agency of the United Nations in 1948. Regional offices throughout the world initiate projects and carry them out. The goal of the organization is "the attainment by all peoples of the highest possible level of health." The WHO is responsible for international narcotics control and biological standardization of drugs, and conducts widespread campaigns against many devastating diseases. In addition, it serves as a clearinghouse for health information. Perhaps one of its most notable programs is its plan to eradicate malaria on a global basis. To date, the program has been quite successful, and over one *billion* people are now free from the threat of malaria in the world.

UNICEF

The United Nations Children's Fund is a branch of the UN whose activities are exclusively devoted to helping children. It, too, campaigns against the major diseases of the world. UNICEF is financed by the voluntary contributions of governments and private groups of people from various countries.

FAO (Food and Agriculture Organization)

The FAO is a specialized agency of the United Nations whose main purpose is to relieve the hunger and inadequate nutrition which afflict half the world's population. It carries out many programs in cooperation with WHO and UNICEF.

CARE/MEDICO

The humanitarian work of Dr. Tom Dooley in a northern Laotian village had far-reaching effects. Not only did he tend to the ills of the people

there, but he taught and trained them to run their own hospital. In 1958, Dr. Dooley spearheaded the founding of an organization called MEDICO (Medical International Cooperation Organization). MEDICO is a program which allows therapeutic medicine to be practiced for sick people in areas that had little or no chance of receiving medical aid. In 1964, MEDICO and CARE merged. CARE supplied the money and logistical support, and MEDICO supplies the doctors.

SS Hope

Project HOPE was begun in 1950 when an unused navy hospital ship was refitted and named the SS Hope. This ship travels to foreign countries and provides medical assistance as well as training. Since it began, Project Hope has trained over 3,000 medical personnel and stimulated the development of medical facilities in many parts of the world.

Other Organizations

There are other private and public organizations devoted to helping in the cause of world health. Medical missionaries, the Peace Corps, and the U. S. Public Health Service, all provide assistance with health programs in many parts of the world.

II. DESCRIPTION OF THE MODEL USED

A. Source of Model

MALAR's model is based on a malaria eradication formula published by the United States Department of Public Health. This simple model has been revised in such a way that the interaction between the four basic treatments can be modeled.

Costs and effectiveness values were established through the aid of Dr. G. Gramiccia (Chief Epidemiological Assessment, Division of Malaria Eradication, World Health Organization, Avenue Appia, 1211 Geneve 27, Switzerland). Morbidity and mortality date are based on estimates collected during the 20th century in the United States (see Figure 2, this section).

B. Program Variables for MALAR

The following variables are used in the *MALAR* program. The numbers in parentheses are the values presently assigned to each variable. Some of these values can easily be altered, and directions for doing so are given in part C of this section.

Program Variables for *MALAR*

Variable	Meaning
C	Cost of current program
C1	Cost of hospital program
C2	Cost of therapeutic drug program
C3	Cost of mosquito spraying program
C4	Cost of preventive drug program
C6	Unspent funds if budgeting; *OR* past allocations if not budgeting ($500,000)
C7	Five-year budget allocation if budgeting ($500,000)
C8	Budget holder for five-year period if budgeting; *OR* total allocation if not budgeting
E1	Actual efficiency totalizer for hospital program (0)
E2	Actual efficiency totalizer for drug program (0)
E3	Actual efficiency totalizer for mosquito spray program (0)
E4	Actual efficiency totalizer for preventive drug program (0)

F	Fatalities in current year
G	Total deaths due to malaria (0)
H	Number of doses of preventive drug to be ordered per year
H1	Actual effectiveness of preventitive drug program
L3	Base cost per person for mosquito spray program
M	Number sick with malaria
N	Five-year program year counter
P	Therapeutic drug doses to be ordered per year
P1	Actual effectiveness of therapeutic drug program
Q	Temporary response and randomizer holder
R	Number of hospital beds
R1	Actual effectiveness of the hospital program
R3	Effective numbers of beds available per year
S1	Number of years with some surplus in hospital beds (0)
S2	Surplus doses of therapeutic drug still good (0)
S4	Surplus doses of preventive drug still good (0)
S5	Surplus doses of preventive drug past use (0)
S6	Surplus doses of therapeutic drug past use (0)
V	Desired effectiveness of mosquito spraying program
V1	Actual effectiveness of mosquito spray
X	Year number counter
Y	Years in use counter
Y1	Years hospital program in use
Y2	Years therapeutic drug program in effect
Y3	Years mosquito spraying used
Y4	Years preventive drugs used
Y(z,x)	Treatment use flag holder
Z	Treatment number
Z9	Version flag holder

C. Calculated Effectiveness of Eradication Programs

The effectiveness of the various options are calculated by the formulae given below:

1. Mosquito control program:

$$V_1 = V * .80$$

2. Curative drug program:

$$P_1 = (P/M) * .85$$

3. Field hospital program:

$$R_1 = \frac{P + R}{M}$$ (For values of R less than 50 times the value of P)

4. Preventive drug program:

$$H_1 = (H/A).6$$

D. Calculated Numbers of Sick and Dead Due to Malaria

1. For year 0:

$$M = .25A + Q\sqrt{4500}$$

$$F = .04M + Q\sqrt{.04 * M}$$

where $Q\sqrt{4500}$ and $Q\sqrt{.04 * M}$ give a randomness to the numbers.

2. For other years:

a) If $P_1 > R_1$,

$$M = \left[(1-H_1)(1-V_1)\left(2.5 \times 10^4 + Q\sqrt{4500}\right)\right] \quad (1-P_1)$$

$$F = (.04-.036\ P_1)\ M + Q\sqrt{(.04-.036*P_1)M}$$

b) If $R_1 > P_1$,

$$M = \left[(1-H_1)(1-V_1)\left(2.5 \times 10^4 + Q\sqrt{4500}\right)\right](1-R_1)$$

$$F = (.04-.036\ P_1)\ M + B\sqrt{(.04-.036\ P_1)M}$$

where $Q\sqrt{4500}$ and $Q\sqrt{(.04-.036\ P_1)M}$ give a randomness to the numbers.

E. Relative Costs of Mosquito Control Chemicals

A full treatment with *malathion* would cost 3.08 times as much as a full treatment of DDT. A full treatment with *propoxur* would cost 8.5 times as much as a full treatment of DDT. Partial treatments are more expensive in the same ratios.

F. Assumptions Under Which the Model Operates

1) The area under treatment has been subject to malaria for a long time and thus a fraction of the population is assumed to have developed a slight resistance to the disease.

2) In any one year, about 4% of those who are infected will die of complications due to malaria, if they are not treated with drugs; but birthrate is such that the population remains nearly stable.

3) The hospital confinement period for a malaria victim is one year, when there is a shortage of drugs for treating the disease, and about 7 days when there is a sufficient supply.

4) Drug doses for the ill will be used first in the hospitals, if they exist. The surplus will be used on non-hospitalized victims.

5) Treatment is limited to this one area, and surrounding areas are not yet being treated.

6) The birth rate in the area is such that the deaths due to malaria do not significantly lower the population, and it remains at approximately 100,000 throughout the years.

7) The costs quoted in the program are based on data from the World Health Organization, and include administration and personnel costs.

8) The actual effectiveness of any treatment option cannot be 100%. That means, for example, that a 100% mosquito-eradication program will not wipe out 100% of the mosquitoes. This is because some of them have a resistance to insecticides, human error, etc. Other factors reduce the actual effectiveness of other options.

9) Unused drugs lost at 25% per year due to pilferage, spoilage, and other factors.

10) All pesticides used have the same effectiveness. Short-lived pesticides are reapplied often, hence their high cost.

G. Altering the Model

1) Altering the budget allocation

Currently the student is allowed $500,000 should he select the budget option (Version #1). You may wish to alter this amount, depending on the students and the degree of difficulty desired.

Our calculations indicate that the WHO would expect to spend approximately $300,000 on such a program.

The DATA statement in line 48Ø contains the budget allocation. This line currently reads

```
48Ø DATA Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,5E5,5E5,Ø
```

The numbers 5E5,5E5 refer to the allocation (5E5 is a form of 5 times 10^5 or 500,000).

If you wanted to change the allocation to $800,000, the line would be rewritten as:

```
48Ø DATA Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,8ØØØØØ,8ØØØØØ,Ø
```

OR

```
48Ø DATA Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,Ø,8E5,8E5,Ø
```

These forms are equivalent. Note, however, if you use the first form, do not use commas within the number. Also notice that all the other numbers in the line must remain *unchanged*.

These two positions in the above line 48Ø may be altered to any number, and so the budgeted exercise may be made harder or easier to fit your needs and the abilities of your students.

2) Increasing the options

Currently *MALAR* forces the student to order the same number of drugs, amount of mosquito spray, etc., each year that he carries out the particular treatment program. This was done to limit the number of possible treatment strategies. Some teachers may wish to open up *MALAR* to the many additional strategies made possible by allowing the student to use different amounts each year.

To do so, the following changes are made after the *MALAR* tape has been loaded, or called from storage. Type each line as written and return after the last character in each line.

```
 55Ø   PRINT  "DO YOU INTEND TO USE HOSPITALS (1=YES,Ø=NO)";
 567   PRINT  "FOLLOWING YEAR, INPUT NO. OF HOSPITALS TO BE USED"
 58Ø   LET C1=INT(C4*2ØØØ)
 63Ø   PRINT  "DO YOU INTEND TO ORDER DRUGS"
 635   PRINT  "FOR THOSE ILL (1=YES,Ø=NO)";
 652   PRINT  "FOLLOW EACH YEAR WITH THE NO. OF DOSES NEEDED"
 665   LET C2=INT(C4*2)
 72Ø   PRINT  "WILL YOU USE MOSQUITO SPRAY (1=YES,Ø=NO)";
 79Ø   PRINT  "AFTER YEAR NO., TYPE PERCENT MOSQUITOES YOU WANT KILLED"
 792   GOSUB  1515
 8ØØ   LET C3=INT(L3*1E5*C4/1ØØ)
 85Ø   PRINT  "DO YOU INTEND TO ORDER PREVENTIVE DRUGS"
 855   PRINT  "FOR THOSE STILL HEALTHY (1=YES,Ø=NO)";
 872   PRINT  "AFTER YEAR, TYPE NUMBER OF DOSES TO BE ORDERED"
 885   LET C4=INT(C4*.72)
 975   IF Y(3,X)=Ø  THEN 995
 98Ø   LET V1=Y(3,X)*.8/1ØØ
1Ø1Ø   IF Y(4,X)=Ø  THEN 1Ø5Ø
1Ø15   LET H1=(Y(4,X)+S4)/1E5
1Ø3Ø   LET S4=S4+Y(4,X)-1E5
1Ø75   IF Y(2,X)=Ø  THEN 1115
1Ø8Ø   LET P1=(Y(2,X)+S2)/M
1Ø95   LET S2=S2+Y(2,X)-M
112Ø   IF Y(1,X)=Ø  THEN 1185
1125   LET R3=Y(1,X)*2Ø
113Ø   IF Y(Z,X)=Ø  THEN 1155
1135   IF  Y( Z,X)+S2 > 5Ø*Y(1,X)  THEN 115Ø
114Ø   LET R3=Y(Z,X)+S2+Y(1,X)
115Ø   LET R3=51*Y(1,X)
*152Ø
*1525
153Ø   LET C4=Ø
*1535
1565   LET C4=C4+Y(Z,X)
```

**NOTE:* THESE LINES MUST BE DELETED

III. PROGRAM LISTING

```
100 REM   MALAR -- SIMULATION OF ATTACK PHASE TREATMENT
110 REM   OF A MALARIA EPIDEMIC
120 REM   BASED ON COSTS SUPPLIED THROUGH THE W.H.O.
130 REM   ORIGINAL CONCEPT - A. PRISHMAN
140 REM   DEVELOPED BY - J. FRIEDLAND
150 REM   PROGRAMMING - J. FRIEDLAND, S. HOLLANDER
160 REM   COPYRIGHT 1972 - STATE UNIVERSITY OF NEW YORK
170 REM   LATEST REVISION 12/6/72
200 PRINT "DO YOU REQUIRE INSTRUCTIONS FOR MALAR (1=YES, 0=NO)":
210 INPUT O
220 IF O=0 THEN 400
230 IF O<>1 THEN 200
240 PRINT "CURRENT CONDITIONS:"
245 PRINT "      APPROX. POP. OF AREA:100000"
250 PRINT "      APPROX. NO. ILL WITH MALARIA:55000"
255 PRINT "      APPROX. NO. DEATHS/YR DUE TO MALARIA:1000"
260 PRINT
265 PRINT "TO CORRECT THIS SITUATION YOU CAN:"
270 PRINT "      ISOLATE THOSE ILL IN QUARANTINE HOSPITALS"
275 PRINT "      ADMINISTER DRUGS TO THOSE ILL"
280 PRINT "      APPLY PESTICIDES TO KILL MOSQUITOES"
285 PRINT "      GIVE PREVENTIVE DRUGS TO THOSE STILL HEALTHY"
290 PRINT
295 PRINT "THESE ARE THE APPROX. COSTS:"
300 PRINT "      FIELD HOSPITAL OF 20 BEDS: $2000 PER YEAR"
305 PRINT "      DRUG TREATMENT FOR ILL: $2 PER PERSON FOR 1 YR."
310 PRINT "      FULL ANTI-MOSQUITO SPRAY: $ 75000 FOR 1 YEAR"
315 PRINT "          WHEN USING DDT, OTHER SPRAYS HIGHER COST"
320 PRINT "      PREVENTIVE DRUG EFFECTIVE 1 YR.: 72 CENTS PER PERSON"
330 PRINT
335 PRINT "CONSULT YOUR STUDENT MANUAL FOR FURTHER INFORMATION"
400 PRINT"YOU MAY USE MALAR EITHER WITH A BUDGET (VERSION 1)"
410 PRINT"OR WITHOUT A BUDGET (VERSION 2). VERSION NUMBER":
415 INPUTZ9
420 IF(Z9-1)*(Z9-2)<>0THEN400
425 RANDOMIZE
430 DEF FNR(A)=COS(6.283*RND(0))*SQR(-2*LOG(RND(0)))
435 DIM Y(4,5)
440 LET N=0
445 READS2,S4
450 READ S1,S5,S6,E1,E2,E3,E4,C7,C6,G
455 FOR Z=1TO4
456 FORX=1TO5
460 LETY(Z,X)=0
462 NEXTX
465 NEXTZ
470 IFN<>0THEN405
480 DATA 0,0,0,0,0,0,0,0,0,5E5,5E5,0
```

```
485 IF Z9=1THEN495
490 LETC6=0
495 LETC6=C6
500 PRINT
505 PRINT"YOUR OBJECTIVE IS TO MINIMIZE MALARIA FOR THE NEXT"
510 IF Z9=2THEN525
515 PRINT"5 YEARS, WITH A TOTAL FUND OF "1C6/1E3;" THOUSAND DOLLARS"
520 GOTO 530
525 PRINT"FIVE YEARS."
530 GOSUB 1675
535 PRINT"   (HOSPITALS)"
540 PRINT
545 LET Z=1
550 PRINT"HOW MANY FIELD HOSPITALS DO YOU INTEND TO USE";
555 INPUTR
560 IFR<=0THEN610
565 IFR<>INT(R)THEN550
570 GOSUB 1515
575 LETY1=Y
580 LETC1=INT(R*Y*2000)
585 LETC=C1
590 GOSUB1585
595 IFC=.5THEN550
600 GOTO610
610 GOSUB1675
615 PRINT"   (DRUGS FOR SICK)"
620 PRINT
625 LETZ=2
630 PRINT"HOW MANY FULL TREATMENTS OF DRUGS"
635 PRINT"FOR THE ILL, SHOULD BE ORDERED PER YEAR";
640 INPUT P
645 IFP<=0THEN690
650 IFP<>INT(P)THEN630
655 GOSUB1515
660 LETY2=Y
665 LETC2=INT(2*P*Y)
670 LETC=C2
675 GOSUB1585
680 IFC=.5THEN630
685 GOTO695
690 LETC2=0
695 GOSUB1675
700 PRINT"   (MOSQUITOES)"
705 PRINT
710 LETL3=.75
715 LETZ=3
720 PRINT"WHAT PERCENTAGE OF MOSQUITOES DO YOU WANT TO ELIMINATE";
725 INPUTV
730 IFV<=0THEN825
735 IFABS(V-50)>50THEN720
740 LETV=V/100
```

```
745 PRINT"WHAT PESTICIDE WILL YOU USE"
750 PRINT"1=DDT        2=MALATHION       3=PROPOXUR"
755 INPUT C
760 IFC=1THEN790
765 IFC<>2THEN780
770 LETL3=L3*3.08
775 GOTO790
780 IFC<>3THEN750
785 LETL3=L3*8.5
790 GOSUB1515
795 LETY3=Y
800 LETC3=INT(L3*185*V*Y)
805 LETC=C3
810 GOSUB1585
815 IFC=.5THEN710
820 GOTO830
825 LETC3=0
830 GOSUB1675
835 PRINT"    (PREVENTIVE DRUGS)"
840 PRINT
845 LETZ=4
850 PRINT"HOW MANY DOSES OF PREVENTIVE DRUGS, FOR THOSE"
855 PRINT"HEALTHY, DO YOU WANT TO ORDER PER YEAR";
860 INPUT H
865 IFH<=0THEN910
870 IFH<>INT(H)THEN850
875 GOSUB1515
880 LETY4=Y
885 LETC4=INT(.72*H*Y)
890 LETC=C4
895 GOSUB1585
900 IFC=.5THEN850
905 GOTO915
910 LETC4=0
915 REM CALC. SECT.
920 PRINT
925 PRINT
930 IFN<>0THEN955
935 LETO=FNR(0)
940 LETM=2.5E4+O*SQR(45000)
945 LETF=.94*M+O*SQR(.04*M)
950 PRINT"USING YOUR PLAN:"
955 PRINT"YEAR","NO. SICK","NO. DEATHS DUE TO MALARIA"
960 PRINT"----","---------","--------------------------"
965 PRINTN,INT(M+.5),INT(F+.5)
970 FORN=1TO5
975 IFY(3,Y)<>1THEN995
980 LETV1=V*.8
985 LET E3=E3+V1
990 GOTO1000
995 LETV1=0
```

```
1333 LETS5=.95*S4+S5
1335 LETS4=INT(.75*S4+.5)
1310 IFY(4,X)<>1THEN1350
1315 LETH1=(H*S4)/1E5
1320 IFH1<1THEN1335
1325 LETH1=1
1330 LETS4=S4+H-1E5
1335 LETH1=H1+.6
1340 LETE4=E4+H1
1345 GOTO1355
1350 LETH1=0
1355 LETO=FNR(0)
1360 LETM=0.5E4*(1-V1)*(1-H1)+0*SQR(4500)
1365 LET S6=.95*S2+S6
1370 LETS2=INT(.75*S2+.5)
1375 IFY(2,X)<>1THEN1115
1380 LETP1=(P+S2)/M
1385 IFP1<1THEN1100
1390 LETP1=1
1395 LETS2=S2+P-M
1100 LETP1=P1*.85
1105 LETE2=E2+P1
1110 GOTO1190
1115 LETP1=0
1120 IFY(1,X)<>1THEN1190
1125 LETR3=23*R
1130 IFY(2,X)<>1THEN1155
1135 IFP+S2>53*RTHEN1150
1140 LETR3=P+S2*R
1145 GOTO1155
1150 LETR3=51*R
1155 LETR1=R3/M
1160 IFR1<=1THEN1175
1165 LETR1=1
1170 LETS1=S1+1
1175 LETR1=R1*.97
1180 LET E1=E1+R1
1185 GOTO1195
1190 LETR1=0
1195 IFR1>P1THEN1205
1200 LET R1=P1
1205 LETM=(1-R1)*M
1210 LETF=(.04-.036*P1)*M+0*SQR((.04-.036*P1)*M)
1215 IFF>0THEN1225
1220 LET F=0
1225 LETG=G+INT(F+.5)
1230 PRINTX+N,INT(M+.5),INT(F+.5)
1235 NEXTX
1240 REM EVAL.S=CT.
1245 PRINT
```

82

```
1250 PRINT"OVER YOUR ";N+5;" YEAR TREATMENT PROGRAM"
1255 PRINTG;" DEATHS DUE TO MALARIA HAVE BEEN RECORDED"
1260 PRINT
1265 PRINT"DO YOU WISH AN EVALUATION (1=YES, 2=NO)";
1270 INPUT O
1275 IFO=0THEN1410
1280 IFO<>1THEN1260
1285 PRINT
1290 PRINT
1295 PRINT"TOTAL COST ";C8-C6;" DOLLARS"
1300 IFC1+C2+C3+C4=0THEN1410
1305 PRINT"PROGRAM","COST","YEARS","EFFECTIVENESS (PCT.)"
1310 PRINT"-------","----","-----","--------------------"
1315 IFC1=0THEN1325
1320 PRINT"HOSPITALS",C1,Y1,INT(E1*1000/Y1)/10
1325 IF C2=0THEN1335
1330 PRINT"DRUG TREAT",C2,Y2,INT(E2*1000/(2)/10
1335 IFC3=0THEN1345
1340 PRINT"MOSQ SPRAY",C3,Y3,INT(E3*1000/Y3)/10
1345 IFC4=0THEN1355
1350 PRINT"PREVENT DRUG",C4,Y4,INT(E4*1000/(4)/10
1355 IFS1+S2+S4+S5+S6=0THEN1410
1360 PRINT
1365 PRINT"SURPLUS ORDERING:"
1370 IFS1=0THEN1380
1375 PRINTS1;" YEARS SURPLUS IN SOME UNOCCUPIED BEDS"
1380 IFS2+S6=0THEN1395
1385 PRINTINT(S2+S6);" TREATMENTS OF DRUGS FOR SICK UNUSED"
1390 PRINT"OF THESE ";INT(.75*S2+.5);" DOSES ARE STILL USABLE"
1395 IFS4+S5=0THEN1410
1400 PRINTINT(S4+S5);" DOSES OF PREVENTIVE DRUG NOT ADMINISTERED"
1405 PRINT"OF THESE ";INT(S4*.75+.5);" DOSES ARE STILL USABLE"
1410 PRINT
1415 PRINT"DO YOU WANT TO (1) TAKE THE NEXT FIVE YEARS"
1420 PRINT"OR (2) START OVER  OR (3) END. TYPE NUMBER";
1425 INPUTO
1430 IFO=1THEN1455
1435 IFO=3THEN1700
1440 IFO<>2THEN1410
1445 RESTORE
1450 GOTO440
1455 IFA0=2THEN1495
1460 IFC6<=0THEN1475
1465 PRINT"YOUR FUND HAS BEEN CREDITED WITH YOUR CURRENT"
1470 PRINT"BALANCE OF $";C6
1475 LETC6=C6+C7
1480 LETN=N+5
1485 RESTORE
1490 GOTO450
1495 LETN=N+5
```

```
1500 LETC6=C8
1505 RESTORE
1510 GOTO450
1515 PRINT
1520 PRINT"FOR THIS TREATMENT:"
1525 IFC<>0THEN1540
1530 PRINT"INDICATE YEARS TO BE USED BY TYPING, AFTER THE YEAR,"
1535 PRINT"1=YES OR 0=NO"
1540 LETY=0
1545 FORX=1TO5
1550 PRINT"YEAR";X+N;
1555 INPUTY(Z,X)
1560 IF Y(Z,X)=0THEN1575
1565 IFY(Z,X)<>1THEN1535
1570 LET Y=Y+1
1575 NEXTX
1580 RETURN
1585 PRINT"COST OF THIS TREATMENT: $";C
1590 IFZ9=1THEN1610
1595 LETC8=C8+C
1600 PRINT"TOTAL MONEY ALREADY ALLOCATED FOR ";N+5;" YEARS $";C8
1605 RETURN
1610 LETC6=C6-C
1615 IFC6<0THEN1630
1620 PRINT"THIS LEAVES A BALANCE OF ";C6;" DOLLARS"
1625 RETURN
1630 LETC6=C6+C
1635 LETC=.5
1640 PRINT"YOUR LAST ITEM OVERSPENT YOUR BUDGET"
1645 PRINT"RESET THIS EXPENDATURE SO IT IS WITHIN THE $";C6;" REMAINING"

1650 RETURN
1675 PRINT
1680 FOR X=1TO49
1685 PRINT"-";
1690 NEXTX
1695 RETURN
1700 END
```

IV. ADDITIONAL SAMPLE RUNS

RUN 1: NO BUDGET; LARGE EXPENDITURE; POOR RESULTS

```
DO YOU REQUIRE INSTRUCTIONS FOR MALAR (1=YES, 0=NO) ?0
YOU MAY USE MALAR EITHER WITH A BUDGET (VERSION 1)
OR WITHOUT A BUDGET (VERSION 2). VERSION NUMBER ?2

YOUR OBJECTIVE IS TO MINIMIZE MALARIA FOR THE NEXT
FIVE YEARS.

---------------------------------------------------  (HOSPITALS)

HOW MANY FIELD HOSPITALS DO YOU INTEND TO USE ?200

FOR THIS TREATMENT:
INDICATE YEARS TO BE USED BY TYPING, AFTER THE YEAR,
1=YES OR 0=NO
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 2000000
TOTAL MONEY ALREADY ALLOCATED FOR  5  YEARS $ 2011000

---------------------------------------------------  (DRUGS FOR SICK)

HOW MANY FULL TREATMENTS OF DRUGS
FOR THE ILL, SHOULD BE ORDERED PER YEAR ?1000

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 10000
TOTAL MONEY ALREADY ALLOCATED FOR  5  YEARS $ 2010000
```

```
-------------------------------------------------   (MOSQUITOES)

WHAT PERCENTAGE OF MOSQUITOES DO YOU WANT TO ELIMINATE ?3

-------------------------------------------------   (PREVENTIVE DRUGS)

HOW MANY DOSES OF PREVENTIVE DRUGS, FOR THOSE
HEALTHY, DO YOU WANT TO ORDER PER YEAR ?1000

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 3600
TOTAL MONEY ALREADY ALLOCATED FOR  5  YEARS $ 2813600


USING YOUR PLAN:
YEAR          NO. SICK      NO. DEATHS DUE TO MALARIA
----          --------      -------------------------
 0             24994          937
 1             23653          935
 2             23729          943
 3             23723          937
 4             23664          938
 5             23759          951

OVER YOUR  5  YEAR TREATMENT PROGRAM
 4641  DEATHS DUE TO MALARIA HAVE BEEN RECORDED

DO YOU WISH AN EVALUATION (1=YES, 0=NO) ?0

DO YOU WANT TO (1) TAKE THE NEXT FIVE YEARS
OR (2) START OVER  OR (3) END. TYPE NUMBER ?3


TIME:  2.28 SECS.

READY
```

RUN 2: NO BUDGET; CONTROL MEASURES ONLY FOR FIRST THREE YEARS; POOR RESULTS

```
DO YOU REQUIRE INSTRUCTIONS FOR MALAR (1=YES, 0=NO) ?0
YOU MAY USE MALAR EITHER WITH A BUDGET (VERSION 1)
OR WITHOUT A BUDGET (VERSION 2). VERSION NUMBER ?2

YOUR OBJECTIVE IS TO MINIMIZE MALARIA FOR THE NEXT
FIVE YEARS.

---------------------------------------------------  (HOSPITALS)

HOW MANY FIELD HOSPITALS DO YOU INTEND TO USE ?200

FOR THIS TREATMENT:
INDICATE YEARS TO BE USED BY TYPING, AFTER THE YEAR,
1=YES OR 0=NO
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?0
YEAR 5  ?0
COST OF THIS TREATMENT: $ 1200000
TOTAL MONEY ALREADY ALLOCATED FOR  5  YEARS $ 1200000

---------------------------------------------------  (DRUGS FOR SICK)

HOW MANY FULL TREATMENTS OF DRUGS
FOR THE ILL, SHOULD BE ORDERED PER YEAR ?1000

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?0
YEAR 5  ?0
COST OF THIS TREATMENT: $ 6000
TOTAL MONEY ALREADY ALLOCATED FOR  5  YEARS $ 1206000
```

```
--------------------------------------------------  (MOSQUITOES)

WHAT PERCENTAGE OF MOSQUITOES DO YOU WANT TO ELIMINATE ?60
WHAT PESTICIDE WILL YOU USE
1=DDT        2=MALATHION        3=PROPOXUR
 ?1

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?0
YEAR 5  ?0
COST OF THIS TREATMENT: $ 135000
TOTAL MONEY ALREADY ALLOCATED FOR  5  YEARS $ 1341000

--------------------------------------------------  (PREVENTIVE DRUGS)

HOW MANY DOSES OF PREVENTIVE DRUGS, FOR THOSE
HEALTHY, DO YOU WANT TO ORDER PER YEAR ?1000

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?0
YEAR 5  ?0
COST OF THIS TREATMENT: $ 2160
TOTAL MONEY ALREADY ALLOCATED FOR  5  YEARS $ 1343160


USING YOUR PLAN:
YEAR          NO. SICK        NO. DEATHS DUE TO MALARIA
----          --------        -------------------------
 0             23075                  987
 1             11751                  444
 2             11690                  422
 3             11783                  451
 4             24978                  980
 5             25114                 1058

OVER YOUR  5  YEAR TREATMENT PROGRAM
 3364  DEATHS DUE TO MALARIA HAVE BEEN RECORDED

DO YOU WISH AN EVALUATION (1=YES, 0=NO) ?0

DO YOU WANT TO (1) TAKE THE NEXT FIVE YEARS
OR (2) START OVER  OR (3) END. TYPE NUMBER ?3


TIME:  2.45 SECS.

READY
```

NOTE HIGH INCIDENCE OF MALARIA AFTER CONTROLS ARE REMOVED

RUN 3: BUDGET; NO HOSPITALS USED; GOOD RESULTS

```
DO YOU REQUIRE INSTRUCTIONS FOR MALAR (1=YES, 0=NO) ?0
YOU MAY USE MALAR EITHER WITH A BUDGET (VERSION 1)
OR WITHOUT A BUDGET (VERSION 2). VERSION NUMBER ?1

YOUR OBJECTIVE IS TO MINIMIZE MALARIA FOR THE NEXT
5 YEARS, WITH A TOTAL FUND OF  500  THOUSAND DOLLARS

-------------------------------------------------   (HOSPITALS)

HOW MANY FIELD HOSPITALS DO YOU INTEND TO USE ?0

-------------------------------------------------   (DRUGS FOR SICK)

HOW MANY FULL TREATMENTS OF DRUGS
FOR THE ILL, SHOULD BE ORDERED PER YEAR ?7500

FOR THIS TREATMENT:
INDICATE YEARS TO BE USED BY TYPING, AFTER THE YEAR,
1=YES OR 0=NO
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 75000
THIS LEAVES A BALANCE OF  425000  DOLLARS

-------------------------------------------------   (MOSQUITOES)

WHAT PERCENTAGE OF MOSQUITOES DO YOU WANT TO ELIMINATE ?100
WHAT PESTICIDE WILL YOU USE
1=DDT        2=MALATHION        3=PROPOXUR
 ?3

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 3187500
YOUR LAST ITEM OVERSPENT YOUR BUDGET
RESET THIS EXPENDATURE SO IT IS WITHIN THE $ 425000  REMAINING
WHAT PERCENTAGE OF MOSQUITOES DO YOU WANT TO ELIMINATE ?100
WHAT PESTICIDE WILL YOU USE
1=DDT        2=MALATHION        3=PROPOXUR
 ?1

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 375000
THIS LEAVES A BALANCE OF  50000  DOLLARS
```

OVERSPENT BUDGET USING PROPOXUR. FORCED TO SWITCH TO DDT.

```
------------------------------------------------    (PREVENTIVE DRUGS)

HOW MANY DOSES OF PREVENTIVE DRUGS, FOR THOSE
HEALTHY, DO YOU WANT TO ORDER PER YEAR ?12000

FOR THIS TREATMENT:
YEAR 1  ?1
YEAR 2  ?1
YEAR 3  ?1
YEAR 4  ?1
YEAR 5  ?1
COST OF THIS TREATMENT: $ 43200
THIS LEAVES A BALANCE OF  6800  DOLLARS


USING YOUR PLAN:
YEAR          NO. SICK       NO. DEATHS DUE TO MALARIA
----          --------       -------------------------
 0             24936          968
 1             699            7
 2             703            8
 3             697            7
 4             685            4
 5             687            4

OVER YOUR  5  YEAR TREATMENT PROGRAM
 30  DEATHS DUE TO MALARIA HAVE BEEN RECORDED

DO YOU WISH AN EVALUATION (1=YES, 0=NO) ?1


TOTAL COST  493200  DOLLARS
PROGRAM       COST           YEARS          EFFECTIVENESS (PCT.)
-------       ----           -----          --------------------
DRUG TREAT     75000          5              85
MOSQ SPRAY    375000          5              80
PREVENT DRUG   43200          5              7.2

SURPLUS ORDERING:
 14361  TREATMENTS OF DRUGS FOR SICK UNUSED
OF THESE  6600  DOSES ARE STILL USABLE

DO YOU WANT TO (1) TAKE THE NEXT FIVE YEARS
OR (2) START OVER  OR (3) END. TYPE NUMBER ?3


TIME:  2.68 SECS.

READY
```

V. FURTHER INSTRUCTIONAL USES FOR THE UNIT

1) As with most simulation programs, a good supplementary exercise for students is to examine carefully the model which underlies the program and determine some changes or extensions which could be made. Comparisons can be made between results obtained with the present model and those obtained with the new model.

2) In the United States, there is strong pressure to ban the use of DDT for all purposes, including malaria control. Using *MALAR*, have the students explore the possibility of running a successful attack phase program without DDT.

   a) Can they be successful using alternative pesticides and still stay within the budget?

   b) Can they be successful without any pesticide?

VI. SUGGESTED SUPPLEMENTARY PROJECTS

1) Organize and conduct a debate on the use of DDT. Try to get access to the reports and papers used by the Federal Government which led to the ban on DDT use in June of 1972. If you are able, try to talk to farmers, public health people, and ecologists to prepare for the debate.

2) Make a study of the major world health problems. Explore the consequences of these and the steps that are being taken to solve them.

3) Make a study of the health services in your community. Try to determine whether they are adequate, whether people know about them, and what services they perform. If appropriate, organize some groups to work with the health services program.

4) Find out how adequately informed students in your school are about some major health problems which are of particular concern to adolescents, such as drug abuse, venereal disease, and alcoholism.* If it is appropriate to do so, organize an "information campaign" to provide information services to students. Speakers and films could be used, and a good library of health-related literature could be established.

5) If your school does not already have a health education program, organize a school community committee to plan one that is relevant and useful to students your age.

6) Make a study of entomology, the science that deals with how insects cause diseases in man. Find out which diseases are caused by insects, and what methods are used in treating these diseases.

---

*The HUNTINGTON TWO curriculum unit *STATISTICAL ANALYSIS PROGRAM* (SAP) should be of great help in doing this project.

VII. RELATED BOOKS, ARTICLES, FILMS AND OTHER INSTRUCTIONAL RESOURCES

Books

Carson, Rachel, *THE SILENT SPRING*
New York: Fawcett Publications, Inc. (1970) (Paperback:95¢)

James, M. T., and Harwood, R. F., *MEDICAL ENTOMOLOGY*
London: The Macmillan Company (1969)

This book deals with the biology and control of all medically significant arthropods. It focuses on important clinical and public h[illegible] problems and on general principles of pest control. Material on epidemiology and the evolution of animal parasitism is also included. The book is probably too sophisticated for most high school students, but could be used as a resource by more advanced students and by teachers.

Sinacore, J. S., *HEALTH: A QUALITY OF LIFE*
New York: The Macmillan Company (1968).

This is a general health studies book which addresses the vital health issues of the time. Although it is probably in general too sophisticated for the average high school reader, parts of it are appropriate for secondary level. Part VII of the text deals with community and global health, and is particularly relevant to the *MALAR* unit.

Williams, G., *PLAGUE KILLERS*
New York: Scribner & Sons (1969)

Articles

"DDT: Criticisms, Curbs are on the Upswing"
SCIENCE 164:936-7, May 23, 1969.

This is a short, general reveiw of the highlights and actions of the federal government with respect to the DDT issue. It describes the major events in the controversy which followed the FDA seizure of DDT-contaminated Lake Michigan coho salmon.

"Malaria Wins Round Two," Gilmore, C. P.
NEW YORK TIMES MAGAZINE, September 25, 1966, p.44 ff.

This is a very interesting, easy-to-read article which describes the devastating effects of malaria throughout the world, and the research work that is being done to conquer the disease. It describes a malaria test program which was carried out in a federal prison in Atlanta by the U. S. Public Health Service. It discusses the use of insecticides as a malaria-prevention measure, and talks about the problems of insect resistance to drugs. It also considers the many other problems encountered by the WHO in the attempt to eradicate malaria from the world.

"Malaria and Victory in Vietnam," Modell, W.
SCIENCE 162:1346-52, December 1968.

This article describes the contributions of the military to the fight against malaria. It tells the interesting story of how malaria was controlled during World War II and describes the research that ensued. It also gives an account of the problem which arose in Vietnam when a drug-resistant strain of malaria developed and of the research program that resulted at the Walter Reed Army Institute of Research.

"DDT in the Biosphere: Where Does It Go?" Woodell, G., et al.
SCIENCE 174:1101-7, December 10, 1971.

This is an interesting and well-written article that describes the use of DDT in the U. S., and the effects of the pesticides on soils, the atmosphere, the oceans, and the biota. It describes a model developed by the author for DDT circulation in the biosphere.

Films

"MALARIA: BLOOD DISEASE AND GLOBAL MAN-KILLER"
(Black and white, sound, 29 minutes,
call number: 81925, 5-day rental:$4.40)

This film introduces the layman and the scientist to recent developments in malaria and related blood diseases of man and domestic animals. It shows malaria as the major worldwide cause of disease and death in the tropics and subtropics. Drug-resistant strains of the causative organism and pesticide-resistant mosquitoes are shown and described. The film also discusses new tests for malaria and current related research at the University of Illinois. The film is available from:

Visual Aids Services
Division University Extension
University of Illinois
Champaign, Illinois 61820

"MODERN MOSQUITO CONTROL"
(Color, 16mm, sound, 26 minutes)

This film shows how new techniques and the insecticide, *malathion*, have made practical, effective, and economical mosquito control available to United States cities. The film is available from:

Modern Talking Picture Service
1212 Avenue of the Americas
New York, New York 10036

or 2000 L Street, NW
Washington, D. C. 20036

Resource Agencies

Council on Environmental Quality
722 Jackson Place, NW
Washington, D. C. 20006

Environmental Protection Agency
1626 K Street, NW
Washington, D. C. 20460

Food and Drug Administration
5600 Fishers Lane
Rockville, Maryland 20852

Health Services and Mental Health
Administration
5600 Fishers Lane
Rockville, Maryland 20852